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Surgery, Gynecology and Obstetrics

WITH

International Abstract of Surgery

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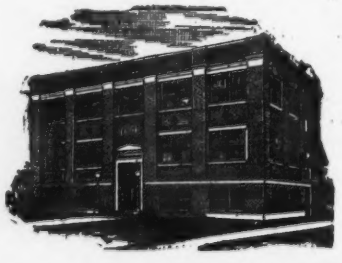

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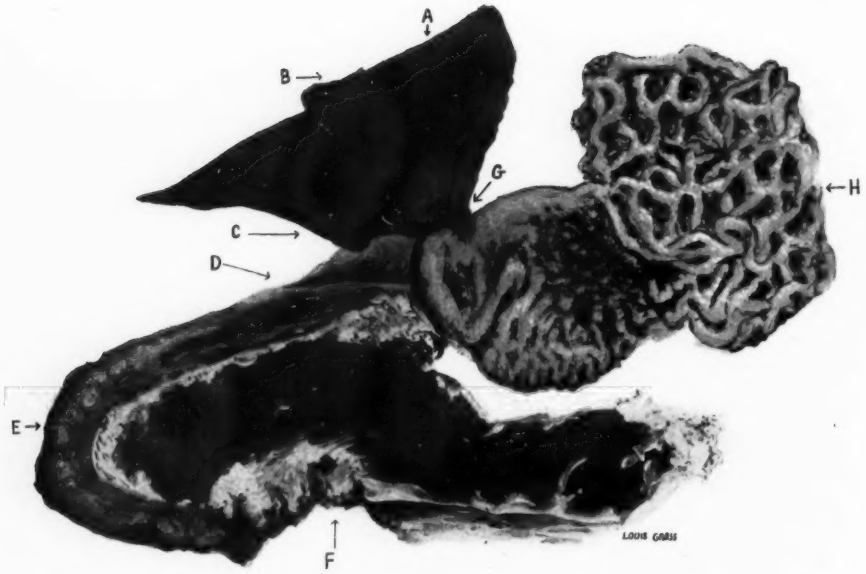

PLATE I.—Painting of specimen preserved in Kaiserling, showing stomach laid open as far as the pyloric ring; the duodenum not opened. The whitish area around the pancreas represents mesenteric fat. *A*, liver; *B*, gall-bladder; *C*, bile-ducts; *D*, approximate entrance of common bile-duct; *E*, duodenum; *F*, pancreas; *G*, pylorus; *H*, stomach.

(*Experimental Production of Pancreatitis in Animals.—Edward Archibald.*)

SURGERY, GYNECOLOGY AND OBSTETRICS

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THE EXPERIMENTAL PRODUCTION OF PANCREATITIS IN ANIMALS AS THE RESULT OF THE RESISTANCE OF THE COMMON DUCT SPHINCTER

BY EDWARD ARCHIBALD, M.D., F.A.C.S., MONTREAL, CANADA
ASSISTED BY MR. BROW, MEDICINE, 1920

A REVIEW of the literature concerning the etiology of pancreatitis which has appeared in the last twenty years reveals the somewhat remarkable fact that observers have apparently been content to remain satisfied with the general idea (well-founded, so far as it goes) that the cause of pancreatitis in some way is closely connected with gall-stones and inflammations of the biliary tract. That this conception of the etiology of the disease fails to account for a large proportion of the cases has, I am sure, been noticed by those who have had any experience in the matter, and have stayed to think about it. On the other hand I am confident it will be generally admitted that this still largely unsolved problem concerning the immediate cause of pancreatitis, and its *modus operandi*, is of great importance; and this because, lacking this key, the door to rational treatment can hardly be opened, or at any rate, opened wide.

In what follows I desire, first, to review, as briefly as may be, the work hitherto accomplished along this line; second, to set down an account of certain experiments and observations which seem to afford a reasonable explanation of the immediate cause of pancreatitis, whether acute or chronic; and, finally, to suggest, as a corollary, the rational treatment.

The history of our knowledge of the etiology of pancreatitis has been summarized in a number of articles during the past few years, and particularly well by Opie (1), by Opie and Meakins (2), and by Guleke (3); so that it is hardly necessary to repeat it here in any detail. If one were to attempt a résumé of our knowledge in this field, it might not unfairly be stated somewhat as follows: The essential *pathological* lesion is necrosis of the pancreatic cells or masses of cells. This is *primary* (Opie and Meakins, 2). Hæmorrhage, inflammation, infection, are all secondary. What has for long been called acute hæmorrhagic pancreatitis ought to be called acute hæmorrhagic necrosis of the pancreas (Opie and Meakins, 2), or better still, simply acute pancreatic necrosis (Guleke, 3). Hæmorrhage, gangrene, and suppuration are merely complications, and frequently do not appear at all. A limited necrosis, remaining aseptic, may be replaced by fibrosis. Extensive mass necrosis results in pancreatic sloughs or sequestra. Chance infection of the necrotic area may result in pancreatic abscess, but is infrequent.

As to the *mode of causation*, a large number of experiments has shown that a variety of irritating substances—practically all of which have been injected into the pancreatic duct or the parenchyma, by means of syringe and

needle—are capable of causing, in animals, the same lesions that are observed in human cases that come to autopsy. The first of these substances was a mixture of bile and sweet oil, which Claude Bernard, in 1856, injected into the pancreatic duct of the dog, causing death in 18 hours from acute hæmorrhagic pancreatitis. A partial list of other substances includes gastric juice (Hlava, 4, 1890); duodenal contents (Polya, 5, 1906); weak solutions of a number of acids such as hydrochloric, nitric, and chromic acids, as also of alkalies (Flexner, 6, 1900); formalin, sweet oil, fatty acids and sodium soaps of the fatty acids; and finally bile (Opie, 7, 1901); the bile salts in pure solution (Flexner, 8, 1906). On the other hand certain substances, which from their bland nature one might anticipate would be unlikely to cause trouble, have been found to do little or no harm; such are blood, blood serum, agar agar, gelatine, paraffin, starch emulsion, and also cultures of certain bacteria when not too virulent or in too great quantity.

Now it is obvious that of all these substances the most natural one to think of as a possible cause of the disease in the human is bile; and as regards this substance we owe the bulk of our knowledge to Opie and to Flexner. In 1901 Opie (7), demonstrated that injection of bile into the pancreatic duct of an animal would cause necrosis of the organ, and at the same time he proved by a now celebrated autopsy observation (from Professor Halsted's clinic) that a *small* gall-stone lodged at the duodenal orifice of the bile papilla might divert bile from the common duct into the pancreatic duct, and in this way set up a fatal hæmorrhagic pancreatitis. A few similar observations have since been recorded (Bunting, 9, 1906; Crowell). In 1906 the solution of the problem was materially advanced by Flexner (8), who demonstrated that the essential constituent of the bile responsible for the necrosing effect in the pancreas lay in the bile salts, of which the taurocholate was much more active than the glycocholate. He also showed that the colloids, that is the mucin and nucleoproteins of the bile, were not only innocuous, but even protective. The mucin, he affirmed, modified the action of the bile salts, the effect being shown in a less fatal character of the experiment, and a less acute and destructive inflammation. That this was due to the colloid nature of the mucin, and not to any directly antagonistic substance contained in it, he proved by using such other colloids as agar, gelatine, and gum arabic, which, being mixed with solutions of the bile salts, secured the pancreas against necrosis in the same way as when the bile contained the proper proportion of mucin and nucleoprotein. He went on to point out that in the human the composition of bile, when imprisoned in the gall-bladder, changes in favor of the mucin constituent, and in the direction of a loss of diffusible salts as the result of inflammatory processes; and he thought that such bile would theoretically be apt to cause subacute or chronic lesions, rather than acute ones. Whether Flexner was correct in either of these assumptions has not yet been demonstrated, and, indeed, there is something to be said against them.

The experimental work of Nordmann (13) came nearest to imitating the conditions of nature. He closed the papilla by purse string suture and then forced bile, or infectious material, into the common duct and so into the pancreatic duct. After purse string suture alone, without injection of anything into the common duct there developed only jaundice, dilatation of bile and pancreatic ducts, and occasionally a few small fat necroses. He also found that bile often entered the pancreatic duct without doing any particular harm. He then added bacteria in the shape of a broth culture, 24 hours old, obtained from the fæces of a dog. Of this he injected one-half a cubic centimeter into the gall-bladder. All such animals died in 48 to 65 hours, with vomiting. In fourteen cases there was typical pancreatitis, with bloody serous exudate, numerous fat necroses, and greatly swollen pancreas, colored dark gray to black, with small and large hæmorrhages. He believed that the necrosing effect on the gland tissue was caused by stagnating infected pancreatic juice, sometimes mixed with bile, and that probably the disturbance was of a chemical nature. He thought the necrosing action

attacked chiefly the interstitial tissue, but sometimes also the gland lobuli.

The theory that duodenal contents might be forced back through the papilla and thence into the pancreatic duct had been maintained in particular by Hess (10), and by Williams and Busch (11), who demonstrated a sort of paralytic dilatation of the mouth of the common duct immediately after a fair sized gall-stone had passed through into the duodenum. They assumed that through this temporarily opened door the duodenal contents might be dammed back by irregular peristalsis into the common duct and the pancreatic duct. This theory still remains theory. In any case, under normal circumstances it has been found impossible, by experiment, such as the complete obstruction of the duodenum below the papilla, to force back the duodenal contents into the common duct (12). Early experiments of the writer, using an iron solution, introduced into a small loop of the duodenum, closed by ligatures from just above to just below the bile opening, under a pressure of 1000 millimeters of water maintained for an hour, demonstrated that none of the solution would enter the bile or the pancreatic ducts.

From the clinical side there soon came apparent support of Opie's hypothesis of the retrojection of bile into the pancreas through gall-stone obstruction at the papilla. Statistics concerning the coincidence of pancreatitis with gall-stone disease, and the location of stones in the various parts of the biliary tract in cases of pancreatitis, were published by Opie, Halsted, Koerte, Ebner, Mayo-Robson, Egdahl, and others. Thus Egdahl (14), for instance, in a series of 105 cases of pancreatitis, found gall-stones present in 44, but only in three was a stone in or near the ampulla. Robson says that the pancreas is involved in 60 per cent of gall-stone cases. Quénu and Duval (15) put it at 50 per cent.

Finally there should be mentioned the theory of Maugeret (16), supported in Germany by Arnsperger (17), and in this country strongly by Deaver (18), to the effect that the cause of pancreatitis is in many cases to be sought in a spread of infection from the gall-bladder wall through lymphatics to the cystic lymph node, thence by a periductal lymphangitis through the nodes along the common duct to those at the head and margin of the pancreas, and thence to the regional lymphatic distribution in the head of this organ. Deaver points out that out of 79 patients with chronic pancreatitis 72, or 91 per cent, showed evidence of infection in the bile passages; 42, or 53 per cent, had gall-stones, and 30, or 38 per cent, had none.

The arguments of a high authority, such as Professor Deaver, demand close examination, and can not lightly be set aside. Yet, to the writer, this conception is difficult of acceptation. It is probably true that cancer cells, say in the breast, when their natural course to the axilla is blocked, may be transported or, as is more likely, may grow in lines by contiguity, backward against the lymph stream, and so produce metastases, apparently anomalous, in the other side of the chest wall or in the epigastric lymph routes. But does this occur in infections? Possibly it does, again by contiguous growth. But does it occur when there is a barrier of lymph nodes to pass? The swollen glands lying above the pancreas are surely more reasonably to be regarded as the result of a primary pancreatic inflammation than as the sign of an infection coming from the gall-bladder and breaking through their guard to reach the pancreas. In cats in which I have caused a pancreatitis, these glands are found acutely swollen, obviously as the *result* of the pancreatic lesion. The demonstration of the possibility of injecting the lymphatics of the head of the pancreas from those of the gall-bladder, or cystic duct, is but small proof of the assumed fact that infectious material actually does take such a route. The lymph nodes draining any organ serve as a barrier to retrograde infection coming to that organ from elsewhere. It is most unlikely that the pancreas should be invaded by the lymph route. Not only is this the case, but a further argument is found in the fact that rarely is the pancreas the seat of a bacterial inflammation. Cultures from all but the frank abscesses, which are rare, are usually sterile, and sterile also from some of the abscesses. An infection

coming by way of the lymphatics would usually, to judge from analogous experience, be bacterial in origin and in type, and pancreatitis would much more often than is the case be suppurative.

For the sake of completeness, it should be mentioned that there exists a small amount of experimental evidence, and of clinical evidence also, to show that an inflammation of the pancreas can be hæmatogenous in origin. There are, for instance, a few cases on record in which suppurative pancreatitis has been observed as a complication of general infections. Then, again, in such a disease as mumps, observers (Edgecombe, 20; Simourin) have seen symptoms of acute pancreatitis in a few instances. Similarly, in typhoid, influenza, and in one case of mastitis (Dreesmann) has pancreatitis been found. Such clinical evidence is far from convincing as proof of the hæmatogenous origin of the disease. Now that we know how frequently the bile becomes infected, presumably through the liver, in generalized infections, it is quite as legitimate to suppose that the pancreatitis resulted by way of the bile tract as by the blood. Rosenow's recent work, indicating that bacteria can invade the wall of the gall-bladder by way of the blood, and that this localization is very often selective, is extremely suggestive; but even admitting this, it is obvious that the causative factor in pancreatitis is not thereby explained. The infection of the gall-bladder can at most be regarded only as a first step, and not even a necessary step, in the production of pancreatitis.

As a net practical result of all this work, it is probably not unfair to say that clinicians generally have combined, rather loosely, the experimental with the clinical and autopsy, evidence into the general conclusion that pancreatitis is caused by the retrojection of bile into the pancreatic duct, as the result of obstruction by a gall-stone at the outlet of the common duct; and that, when that mechanism is inadmissible, by reason of the absence of stones, the pancreatitis is in some way due to infection of the biliary tract, either by a plug of shreddy mucus blocking the papilla just as a stone might block it, or by a direct spread of infection along lymphatics from the infected gall-bladder wall into the substance of the head of the pancreas—(Deaver, 18).

Now, the fact above mentioned (concerning the large proportion of cases of pancreatic swelling in which stones, and even infection, are absent) has been becoming increasingly obvious to clinicians, and especially to surgeons accustomed to routine palpation of the pancreas in upper abdomen operations. In any case, the writer's attention was forcibly attracted to it by an analysis of some 34 cases of pancreatitis (19) which revealed the fact that in over 50 per cent operation demonstrated the absence of either gall-stones or cholecystitis. The conclusion imposed itself that there must exist some cause of the pancreatic swelling other than those indicated in the foregoing résumé. It seemed obvious that bile, which in experiments reproduced so accurately the pathological lesions of pancreatitis as observed in the human, must be the one altogether likely cause. The problem, therefore, was how to explain its entrance into the pancreas, in the absence of any mechanical obstruction such as a gall-stone or a plug of mucus at the outlet of the common duct. Clearly the obstruction would have to be an anatomical or a physiological one. The problem being thus stated, it seemed only natural to postulate the existence of a sphincter at the outlet of the common duct. At this point the writer was unaware that the existence of such a sphincter had long ago been demonstrated. There was nothing in surgical literature at the time (1911) to indicate that surgeons generally knew of such a thing. As a matter of fact the observation had been made by a physiologist and had remained, like many other physiological observations, of which the bearing on clinical medicine is obvious once they become widely known, more or less hidden in physiological textbooks. A little reflection was sufficient to convince one that there must be a sphincter at that point. For one thing there was the well-known fact that the discharge of bile into the duodenum is intermittent, while the secretion of bile is continuous. There was

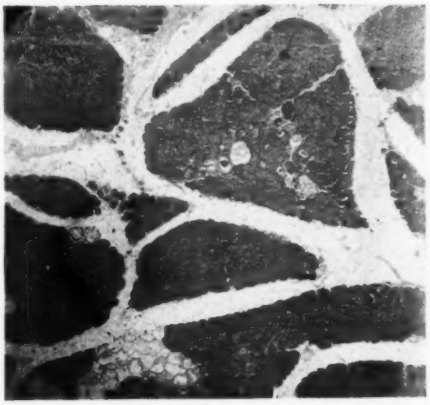

Fig. 1. Cat 86. Low power microphotograph. Many of the vacuolar spaces seen inside the lobules contain, in the stained specimen, yellow, amorphous substance, which represents very possibly the bile forced into the finer ducts of the pancreas. In other spaces there are capillaries showing pinkish-red, presumably representing blood, although blood elements are indistinguishable in the general necrosis. Some of the spaces seem to represent total necrotic cells, or groups of cells, of which only the cell outline remains as shadows. The lack of all definition seen in the photograph represents total necrosis.

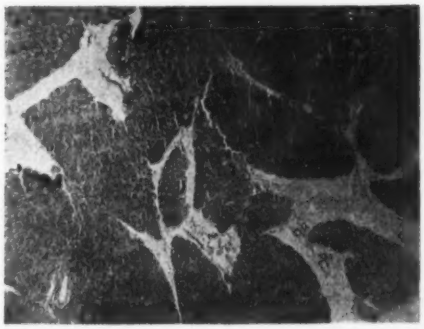

Fig. 2. Cat 90. Low power microphotograph. In this specimen the definition is a shade better than in Cat 86, but the necrosis is still seen to be quite marked. Nuclei can be seen but the protoplasm of the cells of whole lobules is so necrotic that it looks as if it has been melted. Cell outlines can no longer be made out. The cells have run together and the tissue looks smudgy.

also the fact that the bile ducts dilate after the gall-bladder is removed, a result which could only be attributed to some normal obstructing action at the end of the common duct. Acting on this assumption, an experiment was performed on a dog, which demonstrated in a few moments the existence of such a sphincter. With a cannula in the gall-bladder, attached to a funnel holding a methylene blue solution, and with the duodenum open exposing the bile papilla, the fluid was observed to run through into the duodenum intermittently at any pressure which was not a paralyzing one; and, indeed, the muscular contraction of the sphincter, when it braced itself from time to time against the pressure of the fluid behind, could be perfectly well seen with the naked eye.

Some time later a search of the literature revealed the fact that this sphincter had been discovered, and thoroughly described, by the Italian physiologist, Oddi (21, and 22) who published two or three papers on the subject in the years 1887 and 1888. Appearing as it did in an Italian journal, and not in one of the better known, Oddi's very important observations escaped general notice. A reference to it is found in the larger textbooks of physiology, but clinicians, both in Europe and America, apparently knew nothing of it, or, if they did, failed to see that it had any bearing on clinical problems. It may, therefore, be of some interest to review briefly his work.

Oddi studied this muscle both physiologically and anatomically. In brief, he found that the sphincter in dogs was able to resist a pressure of 50 millimeters mercury, which equals about 675 millimeters of water. He demonstrated in microscopical sections that the sphincter was composed of a special bundle of circular fibers. He found that the common duct, outside its course through the bowel wall, possesses no muscular fibers. From the physiological side he discovered that this sphincter could be put into spasm by a mechanical irritation of the duodenal mucosa, or by the application of dilute hydrochloric acid in either the duodenum or the stomach; and that even mere cutting of the bowel to expose the papilla would cause spasms lasting from twenty to thirty seconds. Stimulation of the vagus apparently provoked a very prompt and intense contraction of the sphincter. A like result was obtained

by stimulating the central end of the cut sciatic, while stimulation of the sphlancnics had no effect. He also observed dilatation of all the extrahepatic ducts in dogs deprived of their gall-bladder. He thought a catarrhal condition in the duodenum was a stimulus to the sphincter, and that this might explain some cases of icterus where other causes could not be found.

It may be said that, at the time that the writer's experiments were begun, there was no opportunity of becoming acquainted with the original articles of Oddi, so that a considerable number of the earlier experiments were undertaken independently, and, in the result merely served to confirm his work. They were first begun in the fall of 1911, were continued intermittently during 1912 and 1913, and have been resumed during the past year. In a paper published in the *Canadian Medical Association Journal*, July, 1912(23) the early results were recorded very briefly. They amounted to this: that the hydrostatic pressure in the common duct, that is, the pressure which the sphincter at the papilla of Vater will oppose to a column of water, was surprisingly high. The sphincter was rarely completely overcome by any pressure less than 600 millimeters. In this paper the hypothesis was first suggested that small quantities of bile might be forced back into the pancreatic duct by the resistance of the sphincter, and there either cause, or help to maintain, the condition of pancreatitis. In April, 1913 (24) further experiments were recorded in the *Canadian Journal of Medicine and Surgery*, and the suggestion was made that in the operation for pancreatitis, instead of doing a cholecystostomy or cholecystenterostomy, it would be more rational to abolish the sphincter action at the papilla of Vater. It was demonstrated in dogs that this operation reduced hydrostatic pressure in the common duct from a level of 500 to 650 millimeters of water, before the procedure, down to 70 millimeters or less after it; and that this reduction was permanent for as long as eight weeks, at least, after operation. In this way the possibility of the sphincter damming bile back into the pancreatic duct would be permanently obviated.

In this article it was also shown that the operation of cholecystenterostomy, which had been advised by some, as a form of bile drainage, or rather, as a means of diverting the flow of bile from the common duct in the idea of preventing the passage of infected bile past the open mouth of the pancreatic duct, was based on faulty physiology. A cholecystenterostomy, as was shown by experiments, would fail to divert more than a very minute quantity of bile so long as the common duct was not blocked; and inasmuch as in the great majority of cases of pancreatitis the obstruction to the common duct is slight and transitory, the operation of cholecystenterostomy is ordinarily contra-indicated. This by the way.

In an article published in the *Canadian Medical Association Journal*, for February, 1913 (19) upon the diagnosis and treatment of subacute and chronic pancreatitis, it was maintained that the keynote of the treatment of pancreatitis consisted in the insertion of a safety valve in the biliary system in order to obviate any excessive rise of pressure in that system, thus giving the pancreatitis a chance to subside naturally; and that, in cases of considerable swelling and hardness of the gland such a safety valve, preferably a cholecystostomy, ought to be maintained for a much longer period than was generally done. Three months might be considered as not too long, though in milder cases a shorter period might suffice.

The experiments of the year 1913 were directed toward the demonstration of the possibility of driving a solution, introduced by way of the gall-bladder, into the pancreas, through the resisting action of the sphincter. It was found possible, in cats, to flood the pancreas with a solution containing iron, introduced into the gall-bladder at a water pressure of anything from 300 up to 800 millimeters, the iron being found in the pancreas at autopsy by appropriate staining reactions. These results were embodied in a paper read at the 17th International Congress of Medicine, in London, August, 1913 (25). The bearing of this work upon the problem was of course both clear and close.

After a prolonged absence abroad the

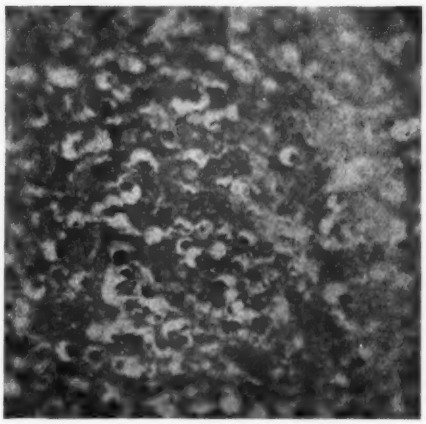

Fig. 3. Cat 94. High power microphotograph. Note the extraordinary degree of necrosis with formation of vacuoles, in which nothing is left but the nucleus, the protoplasm having disappeared. In the denser parts the protoplasm in the stained specimen shows absolute granular necrosis and looks as if melted. Cell outlines are broken down and have largely disappeared.

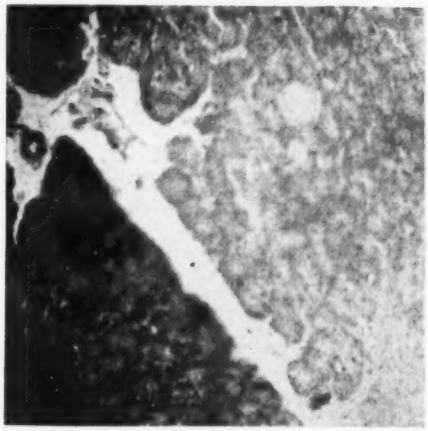

Fig. 4. Cat 96. High power microphotograph. The same necrosis is seen in most of the specimen. At the edge is tissue partly preserved.

problem was again taken up in the Laboratory of Experimental Medicine, of McGill University, in January, 1918, and the present paper records this last group of experiments.

It seemed natural to proceed from the point at which previous work had stopped. The problem now was to induce pancreatitis with bile, by forcing this bile into the pancreas in the same manner as had been done with the iron solution. It may be said that almost as once the experiment was successful, and we were able to produce an acute hæmorrhagic pancreatitis, with death in half an hour. This was in cat No. 86.[1] Certain outstanding experiments will be set down in detail, while the others can be abbreviated. At this point it may be well to indicate that the experiments as a whole may be grouped in three classes, according to the nature of the bile used.

I. Ox-bile infected with various organisms.

II. Human bile from a cholecystostomy case, passed through a Berkefeld filter and autoclaved.

[1] Previous experiments have shown that the dog is an unsuitable animal for experiments of this nature, probably on account of the anatomical fact that the large pancreatic duct in this animal opens directly into the duodenum and not, as in the cat and the human, into the common duct.

III. Solutions of bile salts.

Group 1. Those in which infected ox-bile was used.

Cat No. 86. April 3, 1918. With a cannula tied into the gall-bladder and attached to a funnel with rubber tubing, there was allowed to run in ox-bile which had been inoculated with staphylococcus flavus and incubated for forty-eight hours. Pressure was immediately raised to 500 millimeters. (The normal pressure of bile as secreted in the liver is not over 100 to 150 millimeters.) It was kept at 500 for 45 seconds, after which bile obviously began to run through into the duodenum, as shown by the decreasing level in the funnel. The pressure was then lowered to 100; then raised to 300 for 20 seconds; then to 400 for 20 seconds; at this point the gall-bladder was found to become distended. It was then raised to 500 for 30 seconds, and bile was now observed to run through freely into the duodenum. It was then lowered to 100 and the sphincter thus given a rest for one minute. It was then raised to 200 for 2 minutes, during which time there was no flow into the intestine. Then to 250, and now the flow began into the intestine, but slowly, and in small quantities. It was then lowered to 100 for 30 seconds; then raised to 250 again, when the flow began again in small quantities. It was then lowered to 100 for 30 seconds and raised to 300 for 3 minutes. At this level there was practically no flow. Particles in the glass cannula could be seen, sometimes going into the gall-bladder, at others being forced back; obviously there was intermittent sphincter action. Pressure was now lowered to 100 for 45 seconds, then raised to 350 for 45 seconds and then without further lowering raised suddenly to 600. At this point the sphincter obviously gave

way quickly and there was a free, rapid flow into the duodenum. After 30 seconds it was lowered to 100 and the operation was terminated. The whole procedure lasted about 25 minutes and 80 cubic centimeters of bile were used. It was noticed 20 minutes later that the cat had stopped breathing though the heart was still beating. Measures of resuscitation failed. Immediate postmortem showed a complete hæmorrhagic pancreatitis, from end to end (see frontispiece). The stomach was found to contain about 20 cubic centimeters of the bile used, but it was not congested or abnormal. The duodenum was practically empty, the common duct was not dilated and there was nothing otherwise of note to be found. A culture was taken from the pancreas, with precautions, and a pure growth of the staphylococcus flavus was recovered.

The histological appearances were as follows:

The pancreatic tissue has undergone hyaline necrosis over a large extent. Whole lobules are necrotic; in other places only part of a lobule, the fairly healthy cell passing over gradually into the hyaline masses. Apparently the necrosis has extended from the center of a lobule outward, as the periphery is the best preserved. In many of these areas there is practically no hæmorrhage; in others the capillaries are choked with blood, even into the finest ramifications of vessels, separating individual tubules, but actual escape of blood into the tissue spaces is seen only in a few places and is there not extensive. There are areas of half-way necrosis, indicated by loss of staining of the cytoplasm and of nuclei. The necrosis extends through probably three-fourths of the gland, and it is obvious that a great part would ultimately have been cast off as slough. The individual lobules are enormously separated by clear spaces which represent, probably, an intense œdema. It would seem as if necrosis were the primary lesion and hæmorrhage, preceded by congestion, the secondary lesion.

The same section was stained by Gram's, and it is remarkable how few of the staphylococci are to be seen. In the areas of solid necrosis they are almost entirely absent, except for an occasional capillary, in which one can see a plug of polynuclear cells and cocci. In the congested capillaries cocci are conspicuous by their absence. A few small plugs are found here and there between acini, or between lobules, and these are not in blood-vessels. Search was made for a branch of the pancreatic duct, and in one a clump of extruded cells was found, containing numerous staphylococci, indicating that the entrance path of the infected bile was by way of the pancreatic duct. The same was found in a very minute branch of the pancreatic duct, lying in the center of a lobule. A capillary, containing blood, running just beside it contained no bacteria. Many of the cells lining this small duct were necrotic.

In the hæmotoxylin section it is seen that the branches of the pancreatic duct are lined with necrotic cells, with great loss of nuclear staining, and breaking up of cytoplasm. Even the fibrous tissue of the wall of such ducts stains badly, and is obviously necrotic. At the splenic end the section shows, in general, the same changes as those just described, but if possible, even more extensive. Practically the whole tissue has undergone hyaline necrosis, and the fibrous stroma also is necrotic to a less extent.

Here, then, we have a clear instance of sudden death within 20 minutes of the close of the operation, from a fulminating pancreatitis caused by the forcing of infected bile into the pancreatic duct through the resistance of the common duct sphincter, without there being any other factor whatever in the causation of the lesion. The proof seems complete as regards the rôle which the sphincter of the common duct may take in the causation of pancreatitis.

In another cat we were fortunate enough to reproduce the condition of subacute pancreatitis with death in sixteen days. The experiment was as follows:

Cat No. 84. March 30, 1918. Cannula in the gall-bladder. Ox-bile inoculated with staphylococcus aureus on March 27, incubated for two days, and the third day kept at room temperature. The duodenum was opened for observation. The bile was run in at a pressure of 500, quickly raised to 700. It appeared immediately in the duodenum. Pressure lowered to 100 and flow stopped. Then raised by 50's up to 250, when a little bile came through at the papilla at intervals; then raised to 450, at which a quiet, small flow became continuous. Lowered to 100, flow ceased; raised quickly to 700, and there was an immediate flow of bile through the papilla; lowered to 100, flow ceased; raised quickly to 400, which gave a slight flow, ceasing shortly, so that the sphincter was obviously holding; pressure was then kept at 400, the sphincter still holding, for from 1 to 2 minutes. This ended the experiment, the duodenum and the gall-bladder were closed, and abdominal wound sutured. About 25 cubic centimeters of bile were used and the experiment lasted about 25 minutes. It was considered that the sphincter resisted well at 400 but gave way at 450. At the end of the experiment it was observed that all the pancreas in the neighborhood of the duodenal opening over a length of 1 to 1½ inches was dark red, contrasting strongly with the normal pink color toward the splenic and the lower duodenal end. The cat recovered well and seemed normal for some days. Toward the middle of the second week it refused food, but was not apparently suffering pain. On the morning of April 16 it was found dead but still warm. Postmortem was done within two or three hours. There was marked jaundice in the sclerotics and mucous membranes, which

had probably, to judge from its depth, been present for several days, although the orderly had not noticed it. On opening the abdomen the whole abdominal cavity in front of the omentum and over the anterior surface of the liver was found to be covered with a layer of yellow mush, which could be scraped off very easily, but which, on the liver left in places a rawish surface, indicating a several days' old inflammation. There was a small amount of thick yellow fluid in each flank. In the omentum there were a few spots of fat necrosis; while in the mesentery, behind the pancreas, and especially close to the duodenum, these were quite numerous. The pancreas was diffusely thickened, nodular and hard, being enlarged to about twice its normal size. The thickening was diffuse throughout the organ, but especially marked in the portion adjoining the entrance of the pancreatic duct into the duodenum. The pancreatic tissue looked pale, but also dull and opaque. There was no obvious obstruction in the common duct, but it is probable that the jaundice was due to obstruction at the site of the sphincter, either from pancreatic swelling or from spasm of the sphincter, inasmuch as the yellow mush, found free in the abdomen, was also found in the common duct and a considerable quantity of it in the gall-bladder, while the duodenum was absolutely empty, as also the rest of the small bowel. The escape of this yellow inspissated bile can only have occurred through the fundus of the gall-bladder where a ligature had been applied to close the cannula opening. But this was not clearly demonstrated, as the gall-bladder was cut open carelessly, before this point was determined. The black silk ligature could not be found, but the bile tract from the gall-bladder out to the dome of the liver was continuous, and the dome of the liver also showed the oldest lesions. The liver was yellow, pale, and fatty, and one small abscess was found upon cutting it open. Death was probably due rather to this infective hepatitis and to the peritonitis, caused by the exit of infected bile, than to the pancreatitis. A smear from the peritoneal exudate, stained with methylene blue, revealed no pus cells but only amorphous débris, with many minute needle crystals.

Microscopic sections showed the following: (1) At the duodenal end there is marked œdema with great separation of acini. In parts the tissue seemed well preserved but over a large portion of it the cells and the acini are much degenerated, and loosened from their basement membrane; they have lost their nuclei and lie scattered and independent. The structure of the gland is broken up with loss of the acinar arrangement. There are no foci of necrosis in mass. Inflammatory signs are lacking. A section stained by Gram's does not show bacteria. (2) Section opposite the pylorus resembles, in general, that of the duodenal end just described, but there is also a patchy infiltration with small round cells, and considerable thickening around blood-vessels, indicating a subacute inflammation which has subsided. It is a picture of early cirrhosis in patches. (3) At the splenic end, there is œdema, increase of the fibrous tissue in the septa, and considerable cell necrosis. The architecture of the gland is partly disorganized.

A section of the swollen gland, lying above the pancreas, shows an acute catarrh with much exudate, and a large proliferation of endothelioid cells, together with some fatty degeneration of cells. The liver shows multiple, small recent abscesses. A section of the omentum shows massive necrosis, together with signs of inflammation, much more marked than in the pancreas.

Cat No. 80. March 16, 1918. Injection with syringe directly into the gall-bladder of about 10 cubic centimeters of a solution of inspissated ox-gall (commercial sample) inoculated with bacillus coli communior and incubated for 48 hours, Specific gravity 1.08. Duodenum opened. Fluid injected several times with short sharp rises in pressure. Application of 5 per cent hydrochloric acid on duodenal mucosa. Sphincter was seen to hold for several seconds, then gave way.

March 17th, found dead, but warm, at 11 a. m. without rigor. Immediate postmortem, probably three to four hours after death. Peritoneum clean and dry. Pancreas adjacent to papilla congested and firmer than rest of organ; otherwise nothing of special interest, except for a large acutely swollen lymph gland at the upper border of the pancreas. Microscopic sections show (1) at *splenic end of* pancreas, numerous hyaline necrotic areas, densely packed. Parenchyma between these areas is œdematous and shows beginning necrosis with loss of cell outline. (2) At the *duodenal end* diffuse, œdematous swelling throughout; marked swelling of cells with many cell necroses, but no mass necrosis, except that a whole alveolus may be necrotic. Vessels filled with coagulated amorphous stuff. (3) At *one inch below pylorus*, little change; merely a slight cloudiness in some areas. (4) Liver shows numerous focal necroses. Cultures taken from the interior of pieces of the pancreas, after thorough cauterization of the surface, gave positive growths of gram negative and gram positive bacilli, with staphylococci. These were found in all parts of the organ; and bacteria could be seen in the stained sections.

Cat No. 81. March 20, 1918. The same bile as used in Cat No. 80, standing for past four days at room temperature; introduced through funnel with cannula in the gall-bladder. Bile run in at a measured pressure, varying from 200 to 800 millimeters, pressure being kept up for 10 to 30 seconds, with intervals of one to five minutes to allow sphincter to recover.

Cat died 1¾ hours after commencement of experiment. Immediate postmortem. Pancreas dull greyish, with faint shade of pink, and on cross section showed slight congestion of capillaries. Toward the tail nearly normal in color; not enlarged. Stomach much congested and filled with bile. Bile in the small intestine down to within a foot of the

cæcum. Lungs: upper lobes clear, right lower very much congested; left lower slightly so. Blood stained fluid in moderate amount in the peritoneum. Cultures, from the peritoneal fluid and from three different areas in the pancreas, remained sterile. One loop culture from the pancreas, near pylorus, gave a growth of a gram positive coccus. There was a much engorged and swollen lymph gland lying on the upper border of the pancreas.

Microscopic sections of the pancreas are in general normal, but in places the cells look as if they had melted or run; they are elongated and fused. The outlines are hazy and the protoplasm dirty-looking, but there are no mass areas of necrosis. The liver shows irregular focal necroses.

Cat No. 82. March 23, 1918. Injection into gall-bladder of ox-bile, inoculated two days previously with bacillus coli communior, and kept in incubator. Specific gravity of bile 1024. With cannula in gall-bladder, and duodenum opened for observation, the bile was introduced, from a funnel, under manometric control. The sphincter, in this case, was very weak, and let bile through in small amounts and in a quiet, almost steady, flow even at 200 millimeters, but not at 150 millimeters; at 250 millimeters, more freely; at 300 rapid steady flow; at 400 profuse flow. Stimulation of duodenal mucosa with 5 per cent hydrochloric had no special effect, save perhaps raising resistance by about 50 millimeters. The funnel was raised slowly and rapidly about eight times, up to 300, 400 or 700. The flow through the papilla always started immediately, showing lack of power in the sphincter, and entrance of bile into pancreas was hardly expected. Cat appeared fairly well at 5 p. m., March 25. Was found dead at 9 a. m. next morning. The postmortem revealed conditions as follows: The liver was very dark, engorged with blood and quite soft. The pancreas was pinkish-grey, slightly swollen, and soft, and showed a few bloody streaks on the surface. There were pin-point specks, of a dull white color, over the posterior surface, possibly minute fat necroses. The other organs appeared normal. Microscopic sections showed, in the duodenal end, œdema with considerable necrosis, granular, not hyaline, in patches, while in the splenic end one necrotic area was found. Cultures taken from the substance of the pancreas in various parts yielded gram negative bacilli, and a gram positive coccus. A small amount of fluid was found between the lobes of the liver, and a culture from this gave the same results. Small portions of the pancreas, thoroughly cauterized in a Bunsen flame, yielded, in broth, similar organisms.

Cat No. 85. April 3, 1918. Cannula in gall-bladder; duodenum not opened. Bile emptied from gall-bladder. A little saline run through at pressure of 700 millimeters. This passed into duodenum. Pressure lowered to 100 millimeters. Ox-bile, alkaline to litmus, inoculated with bacillus subtlis 28 hours previously, run into gall-bladder, at pressure of 600 millimeters, during 30 seconds. Lowered to 100 millimeters for 1½ minutes. Raised to 400 for two minutes. Lowered to 100. Raised to 500 for half a minute. Lowered to 100 for two minutes. Raised to 600 for 45 seconds. Lowered to 100 for four minutes. Raised to 300 for 30 seconds. Cannula removed, leaving some bile in the gall bladder. April 4th, cat found cold and stiff in the morning. Postmortem done at noon, probably fourteen to fifteen hours after death. About 40 cubic centimeters deeply hæmorrhagic serum free in abdominal cavity; none in pleura or pericardium. Pancreas showed slight patches of hæmorrhage in the substance of the pancreas adjoining the papilla, for 1 to 1½ inches on either side. The whole organ was of a dull grayish pink hue, and very soft. One greatly enlarged, congested, and œdematous gland lying on the pancreas at its upper border in the duodenopyloric angle. Stomach contained about 40 cubic centimeters of the bile and a lot of mucus. Duodenum filled with glairy mucus for a foot or more from pylorus, obviously an acute catarrhal inflammation. The lungs were very œdematous and congested in all lobes, with ecchymoses here and there, but air-containing, indeed foamy. Other organs show nothing particular. Death apparently due to acute toxæmia with pancreatitis. The urine at postmortem gave a strong reaction to sugar.

Microscopic examination showed extensive areas of necrosis, but without hyaline change. Many of the nuclei do not stain. This necrosis is definitely ante-mortem; the protoplasm looks coagulated, as if it were "boiled"; the cells are swollen. In the liver there is a very marked parenchymatous swelling, not postmortem in type, together with focal necroses, and small hæmorrhages. There is no particular congestion in the vessels. Part of the gland is well preserved. Sections of the swollen gland show great œdema, and considerable congestion in the capillaries. A piece of the pancreas attached to the gland shows some congestion, some œdema, and partial necrosis in some areas, with much disintegration of the gland structure and loosening of cells.

In sections from the pancreas and from the gland, stained by gram's, bacteria could be found.

Cat No. 87. April 6, 1918. Ox-bile, inoculated 48 hours previously with bacillus pyocyaneus, used. Bile was markedly alkaline. Same procedure followed as in Cat No. 86. Cat found dead at 11:30 a. m., April 7. Immediate postmortem. The pancreas is pinkish, but not particularly swollen. On section there were seen numerous punctate hæmorrhages, especially near the splenic end. The lymphatic glands, above the pancreas, leading to the hilus of the liver, were very much enlarged and congested. The gall-bladder was practically empty. In the duodenum a great deal of mucus, and a small hæmorrhagic area in the submucosa, close to the papilla, were found.

Microscopic sections from the splenic end, show parenchymatous swelling of the cells and degeneration but no definite necrosis. At the duodenal end and at the angle opposite the common duct

there are numerous patches of moderately advanced necrosis, in parts hyaline. In some areas there are also inflammatory foci and one small infarct. The lymph gland lying above the pancreas shows a very acute inflammation, with great œdema, catarrh, necroses, and purulent infiltration. The liver shows numerous focal necroses, and also small, multiple, very early abscesses.

Cat No. 88. April 10, 1918. Ox-bile, inoculated with bacillus prodigiosus six days previously, incubated for 48 hours and afterward kept at room temperature. With a syringe and fine needle 6 to 8 cubic centimeters of this bile was injected slowly into the gall-bladder. The gall-bladder did not become tense to any appreciable extent. Immediately before this 2 cubic centimeters of a 3 per cent hydrochloric acid solution were injected through a fine needle into the duodenum. The cat had fasted for the previous 24 hours. Death followed in three hours. Immediate postmortem showed the pancreas markedly congested, of a deep pink color, involving body and both ends, but trailing off to natural color toward the spleen and the extreme duodenal end. Bloody fluid in abdomen in quite large amount. Thorax normal, except that both sides of heart were dilated. A large amount of mucus, filling stomach and duodenum and upper jejunum, but no submucosal hæmorrhages. Mucosa of duodenum, from papilla to stomach, and also that of stomach of a whitish color, probably due to the hydrochloric acid. Urine gave positive sugar reaction.

Microscopic section shows considerable areas of swollen cells and of possible beginning necrosis, although this is not quite certain. As a whole the pancreas is normal. No bacteria are seen in sections stained by Gram's.

Comment. Death in this case can hardly be said to be due to pancreatic destruction, but there was clearly some very acute toxic process at work, sufficient to kill in a little over three hours. The congestion of the pancreas and the large amount of bloody fluid in the abdomen point in that direction. Presumably the toxine was contained in the infected bile. Whether its path of quickest absorption lay through the pancreas or through the intestinal mucosa can only be guessed.

Cat No. 89. April 10, 1918. Same procedure as in cat No. 88 except that bile used was that which had been inoculated with staphylococcus flavus, and had been standing at room temperature for a number of days. Bile was alkaline. April 15, the cat had recovered easily and was in good condition. Abdomen opened for examination and the animal then killed with chloroform. Immediate postmortem showed nothing of note, except the presence of two large, swollen lymph glands, obviously inflamed, lying on the upper edge of the pancreas just below the pylorus. The pancreas itself was not definitely swollen, but perhaps of a deeper color than normal.

Microscopic sections showed nothing abnormal in the pancreas. In the liver there were small areas of early inflammation, with small focal necroses, and some hyaline thrombi.

GROUP II. EXPERIMENTS WITH FILTERED AND STERILIZED HUMAN BILE

Cat No. 90. April 13, 1918. Human bile, not grossly infected, from a case of cholecystostomy, filtered through a Berkefeld filter, to get rid of bile mucin, then sterilized in autoclave for fifteen minutes. The reaction slightly alkaline. Injection of 2 cubic centimeters of this bile filled the gall-bladder without tension. Then 2½ cubic centimeters of 3 per cent hydrochloric acid injected into the body of the stomach followed by 2½ cubic centimeters of the same into the antrum pylori. Then about 8 cubic centimeters of the bile injected into the gall-bladder through a hypodermic needle; this seemed to pass on into the duodenum, as the gall-bladder did not distend. The cat recovered well and remained in good health.

On April 20, it was chloroformed. Immediate postmortem. The pancreas near the duodenal end was fairly normal; opposite the papilla and from there on to the splenic end, it was definitely thickened and the lobules stood out prominently. No areas of fat necrosis. The gall-bladder contained clean-looking bile and mucosa was healthy. The common duct was not dilated. The duodenum was normal. The urine showed a marked quantity of sugar. Otherwise there was nothing particular to be found.

Microscopic sections show large areas of necrosis in the pancreas with beginning hyaline change. The central area, around the ducts, is especially involved, while the periphery is often preserved. In some parts, especially close to the papilla, there is acute parenchymatous degeneration but no necrosis. Sections of the liver show focal necroses.

Comment. Note the effect of sterile bile deprived of its mucin and consequently containing a disproportionate amount of bile salts. Note also the lack of high pressure from the gall-bladder side and the resistance of the sphincter provoked, probably, by the hydrochloric acid. Also note the presence of marked microscopical changes, without obvious gross lesion.

Cat No. 91, April 15, 1918. Injection of human bile into the gall-bladder with a syringe and a large needle. Bile the same as that used in previous experiment. After expressing gently most of the bile found in the gall-bladder, the bile used in the experiment was injected and the gall-bladder was distended. This was followed immediately by the injection of ½ cubic centimeters of 3 per cent hydrochloric acid into the duodenum, close to the pylorus, which was then milked gently down toward the papilla; then immediate injection of ½ cubic centimeters of hydrochloric acid as before, followed by 4 or 5 more squirts of bile into the gall-bladder, using altogether 13 cubic centimeters of bile. The gall-bladder was not emptied between the injections,

but was relaxed somewhat, so that some bile clearly escaped into the duodenum or the pancreas. The pancreas, examined immediately upon opening the abdomen, was seen to be of a pale pinkish color. Examined again at the close of the experiment, it was found much deeper in color and with blood-vessels standing out prominently. There were also one or two small ecchymoses. One area, in the body of the pancreas, stood out pale by contrast with the deep red of the rest of the organ.

The cat was rather sick for two or three days after the operation, but then regained normal health. On May 30 it was chloroformed. The organs were all apparently normal. The pancreas was moderately pink, but not thickened or otherwise abnormal. There was nothing else of note. No sugar was found in the urine.

Microscopic sections show at the duodenal end very extensive areas of mass necrosis, with hyaline change. In two places apparently small infarcts. At the splenic end no definite necrosis, but in some areas a melting of cell outlines giving a sort of "boiled" look to the tissue. Considerable congestion. In the liver very extensive fatty change chiefly in the periphery of the lobules.

Cat No. 92. April 17, 1918. Injection of 3 cubic centimeters of human bile filtered and sterilized but standing for past week at room temperature, acidulated with 1 drop of hydrochloric acid, C. P. (reaction of bile, previously alkaline, made definitely acid), into gall-bladder, after partial expression, with finger, of bile in the gall-bladder; immediately followed by injection of 1 cubic centimeter of 3 per cent hydrochloric acid into the duodenum, just below the pylorus.

May 31st, chloroformed. The cat had been well since the operation. Pancreas and the other organs were found to be normal.

Microscopic section shows, at the duodenal end, normal appearances, except that in certain areas cell outlines are fused, nuclei stain poorly, and the tissue generally looks as if it had melted. There seems to be definite parenchymatous degeneration, if not necrosis. In some sections these areas are quite extensive.

At the splenic end the appearances are similar to those in the duodenal end. In the center, opposite the papilla, there is a good deal of small cell infiltration and also of young fibrous tissue, chiefly between the acini. Some areas are quite sclerosed, presumably a replacement of former areas of necroses.

These two experiments show that the coincidence of bile deprived of its mucin, with sudden pressure from the gall-bladder side, and increased acidity in the duodenum, is not always sufficient to bring about an injury to the pancreas. Doubtless there must occur a particular combination or sequence of these conditions and activities to cause pancreatitis.

GROUP III. EXPERIMENTS WITH SOLUTIONS OF BILE SALTS

Cat No. 94. May 31, 1918. A solution of sodium glycocholate was made in salt solution of a strength corresponding to the strength of the salt in human bile, and a few cubic centimeters were injected through a fine syringe into the gall-bladder after aspirating the bile present in it. The gall-bladder was not put under tension by the injection. The animal seemed unaffected by the operation. It was chloroformed after 48 hours and postmortem showed the absence of any gross change in the pancreas or other organs. On microscopic examination, however, there was found extensive mass necrosis of the parenchyma, with loss of cell outlines, fusion of the protoplasm, loss of nuclear staining, but without hyaline change. In the liver fairly numerous focal necroses were found.

Comment. The gross appearance of the pancreas was apparently so normal that the discovery of extensive cellular necrosis in the microscopical sections was a great surprise. The fact has been noted by Polya. The necrosing effect of the glycocholate, in this instance, is opposed to the observations of Flexner, who found that the injection of this bile salt into the pancreas caused but little disturbance.

Cat No. 96. May 31, 1918. A solution of sodium taurocholate in the strength normal in human bile was injected into the gall-bladder after aspiration of its bile, using about 6 cubic centimeters in three lots separated by an interval of some ten minutes. The animal did not appear to suffer from the operation. It was chloroformed after 48 hours and postmortem showed the pancreas apparently normal save for slight congestion; but the remarkable finding was a row of fat necroses stretching along the upper margin of the pancreas almost in its entire length. Here again, as in Cat No. 94, the comparatively normal gross appearance of the organ was belied by the discovery of extensive necrosis in the microscopical sections, and moreover, the necrosis was quite as advanced at the splenic end as it was in the neighborhood of the papilla of Vater. The picture was similar to that seen in sections of Cat No. 94.

This case would seem to prove the possibility of the occurrence of fat necroses without gross inflammatory obstruction of the main excretory ducts; also the possibility of mild grades of pancreatitis with symptoms so slight as to escape observation, at any rate in the animal. It suggests the likelihood that there occur cases in the human of mild pancreatic swelling accompanied even by fat necroses, later absorbed, giving clinically indefinite symptoms of epigastric pain lasting only for a short while, such as we see so

frequently in practice, and of which the cause so often remains undiagnosed. Both these operations (Cats No. 94 and No. 96) indicate the possibility, and indeed the probability, that there occur in the pancreas isolated or even extensive necroses, resulting from the entrance of bile into the pancreatic duct, which go on quietly to replacement fibrosis, ending in a moderate sclerosis of the organ which is not sufficient to interfere materially with its function. The condition is found not infrequently at autopsies in patients who have died from other causes, without there being noted in the case histories anything suggestive of a previous pancreatitis. Whipple has called attention to this fact in his animals, and has emphasized the extraordinary capacity of the pancreas to recover in this way from extremely serious necrosing lesions.

From a review of the experiments related above, certain outstanding facts may be deduced. Of these the main one is that the lesions produced in the pancreas by these methods of experimentation were brought about entirely through the action of the common duct sphincter, combined usually, but not always, with some increase of pressure in the biliary system behind the sphincter. That this increase in pressure need be very slight, indeed but little over normal bile pressure in the common duct, or may be even quite absent, is seen in the results obtained in Cat No. 82; also in Cats No. 90, 92, 94, and 96. I would suggest, indeed, that this is the ordinary mechanism at work in human cases, even when gall stones are present. In these animals there was no question of any mechanical obstruction to the outflow of bile into the duodenum. The obstruction was purely a physiological one. While the application of hydrochloric acid to the duodenal mucosa will definitely stimulate the sphincter to a heightened resistance, it is obvious that such hyperacidity is not necessary for the forcing of the bile into the pancreas. Many lesions of the organ were produced without it.

The second fact is that we have been able to produce in this way most of the main types of lesions in the pancreas found in clinical practice. Cat No. 86 is an example of the acute fulminating hæmorrhagic necrosis of the gland with death inside the hour. Cat No. 90 is an example of the generalized increase in size and hardness of the organ so frequently found at operation, with or without fat necrosis. The amount of necrosis in the pancreatic tissue is not so great as to cause sequestration, and it is without doubt replaced gradually, being aseptic, by fibrous tissue. This would represent the ordinary cure of pancreatitis of that grade of severity. Cat No. 96 represents the very mild type of the disease, going on to cure, with a small amount of fat necrosis spontaneously reabsorbed. Cat No. 84 is an example of subacute pancreatitis, with diffuse thickening and some fat necrosis, ending in death after two weeks, and with extensive necrosis of the parenchyma of the pancreas in microscopic sections.

Another interesting point concerns the immediate cause of the necrosis of the pancreatic parenchyma. Some have stated that, in whatever way the initial cell was destroyed, further destruction must be caused by activation of the trypsinogen in the pancreas, presumably by the introduction of enterokinase from the duodenum, or, possibly, by some other activating agent, such as calcium, derived from the blood, the bile, or inflammatory exudate. The experiments, however, above recorded, and also those carried out by previous observers, seem to show very clearly that the necrosis of the pancreas is the direct result of the action of substances entering the duct of Wirsung, such as the bile salts, unmixed with bile colloids, or such as artificial gastric juice, or a whole series of acids and strong alkalies. Recent observations of Tatum(26)and Bradley and Taylor(27) show that bile, or its salts, has a very marked cytolytic effect on the cells of various organs, and that this disintegrating effect is quite distinct from autolysis; that is, that it is not due to the activation of enzymes by bile or to a co-ferment in bile, but represents a straight destructive effect presumably of a chemical nature. The microscopic picture of diffuse parenchymatous necrosis, most marked in the center of lobules surrounding the ramifying ducts, and the hyaline

nature of the necrosis, differing markedly from the picture seen in postmortem autodigestion, would apparently suffice to prove this contention. Thus the necessity of accounting for the entrance of an activating ferment through the papilla and into the pancreas falls to the ground, though it need not be denied that activation and consequent autodigestion may occur secondarily and so increase the original necrosis caused by the entrance of bile. The theory of Williams and Busch, (11) assuming the flow of duodenal contents containing enterokinase back through the papilla dilated by the recent passage of a calculus, would provide the conditions for activation of the trypsinogen. In a like manner the "mucous currents" described by Mr. Bond (28) (who found carmine granules, given by mouth, appearing in the bile from a cholecystostomy—an observation, which, by the way, has been confirmed by the writer in one case out of three) might carry enterokinase up into the common duct. As a matter of fact the writer believes that the extent of necrosis is determined at the very outset of the disease by the grade of virulence and extent of permeation of the noxious agent, very much as in acute osteomyelitis the size of the sequestrum is fixed in the first few hours of the infection. It is possible, of course, that succeeding invasions of bile may increase the extent of necrosis.

A few other points of interest may be noted without discussion in this place. Liver necroses, of the type now well-known as focal necroses (Fischler, 29) occurring in the course of pancreatitis, were found with great regularity, both in fatal and in light cases; and were present within 20 minutes of operation.

The severe cases with early death were all in the series in which infected bile was used. Sterilized mucin-free bile, and the bile salts in solution caused, it is true, necrosis of the gland, but of a degree easily consistent with recovery; while the infected ox-bile almost regularly caused early death, usually with, occasionally without, severe lesions in the pancreas. Possibly the pancreas formed a route of particularly easy absorption. There is here an interesting comparison to be made with the cases of sudden death described by Symmers (30), in which moderate pancreatic necrosis was almost the only lesion found. Note especially in this regard Cats Nos. 81, 82, 85, 87, and 88. Fat necrosis (see Cat No. 90) is possible without acute changes in the pancreas of a reactionary inflammation and without infection.

The histological lesions correspond accurately with those produced by the injection with a syringe of bile, acids, alkalies and other irritants, as carried out by Flexner, Pearce, Hlava, and a number of other observers.

That alteration in the constitution of bile, which, once it is forced into the pancreatic duct, will set up necrosis and inflammation, is fairly well known. It is such as to leave the bile salts, particularly the taurocholate, in undue strength, whether this is accomplished by filtration or, possibly, by the action of bacteria. But the exact combination of circumstances under which such a bile, so altered as to be irritating to the pancreatic cell, is driven into the pancreatic duct is still somewhat unclear. I imagine that normal bile must frequently be forced into the pancreas by the action of the sphincter without doing any harm or causing any symptoms. The conditions for actual damage to be done must pretty certainly be three: first, a change in bile composition, increasing the proportion of bile salts; second, undue resistance, perhaps often amounting to spasm, of the common duct sphincter; and third, abnormal rise of pressure in the biliary system behind, either in the gall-bladder or in the common duct.

Our problem, therefore, is to discover in the facts of clinical experience circumstances fulfilling these postulates. Here we come on to uncertain ground. It is probable that hyperacidity may have a good deal to do with it. Symptoms indicating hyperacidity are frequently found in the previous history of patients with pancreatitis (Egdahl, 14). Certainly the injection of hydrochloric acid into the duodenum or even into the stomach (Oddi) will cause a spasm of the sphincter. In man we are still unacquainted, so far as I know, with the condition of the duodenal

contents as regards the length of time which is necessary for neutralizing the acid chyme of the stomach. In alcoholics, anyhow, and in patients who have duodenal ulcers, it would seem probable that the duodenal contents might remain acid for some time, and in these two classes pancreatitis, is rather frequent. One recalls in this connection three cases published by Dr. William J. Mayo, in which acute pancreatitis was present, without gall-stones anywhere, but with, in each instance, a duodenal ulcer situated close to the papilla, presumably causing hyperacidity.

In the second place, that change in bile which results in a high concentration of bile salts and a diminution of bile mucin is probably brought about by the effect of gall-stones, especially when associated with inflammation. In infected bile, it is pretty certainly not the bacteria acting in their infecting capacity that cause the pancreatic lesion, but rather the chemical change in the bile produced by the action of bacterial growth. This at least was strongly suggested by the work of Flexner, of Carnot, Hlava, and others; and the present experiments, in which sterile bile and a solution of sodium taurocholate caused the lesion equally with infected bile, tend to confirm this view. I am unacquainted with any work upon the chemical composition of infected bile, but it may be presumed that the action of bacteria is to precipitate the mucin of bile; and indeed we see the evidence of it in the shreds observed in the bile in cases of cholecystitis and cholangitis. If this is the case, it is probably contrary to the assumption of Flexner that the relative proportion of the bile salts is increased. I may add that Dr. Harding, Associate Professor of Chemistry in McGill University, is beginning work along this line. It must be pointed out, however, that the effect of bacteria upon the bile seems to increase very greatly the destructive effect of that bile upon the pancreas; and while this is still probably due to some chemical change in the bile it seems likely that there come into play, in addition to the bile salts, new substances possessing necrosing properties.

It may be noted also that any obstruction in the cystic duct would likely deprive the bile of a part of its mucin content normally provided by the gall-bladder mucosa; and in such cases, theoretically at least, the occurrence of a pancreatitis may be rendered more likely.

In the third place the condition of increased pressure in the biliary system is presumably brought about partly by an increased resistance of the sphincter, set in motion by hyperacidity or by neighboring ulcers; partly by a sudden blocking of the cystic duct by stone or inflammation; and finally, perhaps, by any unusual increase in the amount of bile secreted by the liver. The effect of a full meal, two or three hours after which, as we see in so many case reports, the attack of pancreatitis is apt to come on, may be in the direction of increased bile production rather than in that of increased pancreatic secretion.

TREATMENT

In conclusion I would like to say a few words about the bearing of these experiments upon treatment. Accepting this conception of the action of the sphincter, I think it may be concluded that the surgical treatment of pancreatitis must chiefly lie in a prevention of any further retrojection of bile into the pancreas. The damage already done to the organ will often be cured by the processes of nature, absorption, replacement, or even sequestration. On the other hand, if gangrene, abscess, or total slough has occurred, it may require a direct attack upon the pancreas itself. But to prevent recurrence or extension the cardinal point would seem to lie in the prevention of any heightened pressure in the biliary system, and secondly in the restoration of an altered bile to its normal chemical condition, or of an infected bile to sterile bile. This can only be done by a drain in the gall-bladder or in the common duct. Whether one should do a cholecystostomy or a cholecystectomy, with drainage of the common duct, is still a moot question, altogether apart from the condition of the biliary passages and the situation of gall stones in the individual case. Without pronouncing one way or the other in this matter, I would like to point out that in my opinion the essential thing lies in prolonged drainage; that is, prolonged

prevention of any rise in pressure in the bile system. This is more completely done by a drain in the common duct than by one in the gall-bladder, and possibly explains, what we now are inclined to believe is the case, that a cholecystectomy gives a better result than a cholecystostomy. I still think, as suggested in a paper a few years ago, that, in certain cases, the object of preventing a rise of pressure in the biliary system for a long time, or permanently, would be best secured by cutting the common duct sphincter. The after history of a duodenostomy for removal of stone, which always cuts the sphincter, seems to be very good. Such cases might form a middle class between those in which the gall-bladder is apparently normal, and those in which it is so diseased as to demand removal. But in any case, if the pancreas is materially affected, we must assume that nature will require at least three or four weeks, and often two or three months of protection in order to complete her repair work in the pancreas. I, therefore, adopt as a rule prolonged drainage of bile, from one to three months, in all cases of pancreatitis save the very lightest. And I may add that a recent investigation into the late results of our pancreatitis cases at the Royal Victoria Hospital has brought out in a very striking way the value of a drainage kept up for over three weeks, and up to three months; while on the other hand it has shown that a drainage of two weeks and less is followed by a large proportion of recurrences of the pancreatic attacks.

Parenthetically, accepting for the present the conclusion of Judd (31), that a cholecystectomy will more certainly cure pancreatitis than a cholecystostomy, one may hazard the guess that the reason lies in the cutting out of the only muscular force of any strength in the biliary system, thus preventing the rise in pressure associated with the contraction of a muscular organ, and substituting the big capillary system of the liver, capable of absorbing a considerable amount of back pressure, when brought on slowly, as would be the case with the continued resistance of the sphincter.

The interested reader should consult, in this connection, the very excellent clinical and experimental work done in the last two years by Dr. Judd and Dr. Mann, of the Mayo Clinic (31, 33, 34 and 35).

The opinion of some surgeons to the effect that a direct attack in the acute and subacute lesions should be made on the pancreas itself, with the idea of draining that organ, by incisions through its capsule, or by blunt poking into it, is, I think, an erroneous one, founded on a misconception of the pathological condition. One cannot drain a diffuse necrosis. Only in the cases in which such an interference can evacuate collections of pus, or of aseptic turbid fluid, representing the liquefaction of necrotic tissue plus reactionary exudate, can such a procedure be justified. Whipple and Goodpasture(32) have shown that the reactionary peritoneal exudate in acute pancreatitis has protective value; and the frequent recovery, without operation, of cases of a degree of severity less than that of the hyperacute or fulminating form, tends to confirm this view. Whipple, and other investigators, have shown, as a matter of fact, the great capacity of the pancreas to repair damage done to the organ, and it is possible that an excessive zeal in the operative attack upon the pancreas itself has pushed over the brink some cases that might otherwise have got well.

Practically speaking, it is the writer's opinion that surgical intervention should run along the following lines. In hyperacute or fulminating cases, in which death is obviously likely to occur within the first twelve to twenty-four hours, the patients being in collapse, it is better to wait; the shock of operation may turn the scale against them, and it is impossible, short of cutting out all or most of the pancreas, to prevent that absorption of split products from the necrosed tissue of the organ which is the immediate cause of death. These patients cannot be saved. If they do survive it is because the dose of poison stops short of the fatal amount, and not because incisions into the pancreas divert to the exterior a sufficient amount of the poison to turn the balance. It is only fair to add, however, that the administration of ether, in animal work, seems to

mitigate the toxic effects of split product absorption.

In all cases of less severity it is advisable to operate. In the acute cases the object is not to remove peritoneal exudate, which is rather protective than otherwise, or to "coffer-dam" the pancreas (an impossibility it seems to me), but rather and chiefly to drain the biliary system, and so prevent further entrance of bile into the organ. If there is a collection of fluid in the pancreas, this may be incised and drained; otherwise the pancreas should be left alone. The type of operation on the bile passages will vary according to degree of involvement of pancreas.

If the latter is only slightly enlarged and hard, and the gall-bladder is comparatively healthy a cholecystostomy may be done and the bile drained for not less than three weeks. If the pancreas is moderately large and hard, bile drainage should be kept up from four to six weeks. If it is very large and hard, drainage should be maintained for three months, with the alternative (proposed, but not established on a definite clinical basis) of a cutting of the sphincter of Oddi through an opening in the duodenum. In all these cases the gall-bladder should be removed, if, in the opinion of the operator, it is likely to remain a source of infection, in which case the common duct should be drained. In the acute cases, with the patient in a precarious condition, the least degree of interference is probably the best, and that would obviously consist in a cholecystostomy.

In the chronic sclerosing type of pancreatitis, following late after a severe acute attack, with fatty stools and glycosuria, and occasionally jaundice, I believe, on theoretical grounds, that it would be wise to cut the sphincter of Oddi in order to make quite sure that there will be no interference with the easy exit of bile and of whatever small amount of the pancreatic external secretion that may still be produced. A small amount of pancreatic juice will suffice for digestion, and the presence of bile in the intestine is necessary to fat absorption. In one such case in the writer's experience a chronic sclerosis of the gland ended in rapid death from a hyperacute pancreatitis. Jaundice is usually absent in such cases, but if present, and of long standing, and apparently due to obstruction by the enlarged head of the pancreas, a cholecystenterostomy would clearly be better than cutting the sphincter.

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TREATMENT OF PURULENT ARTHRITIS BY WIDE ARTHROTOMY FOLLOWED BY IMMEDIATE ACTIVE MOBILIZATION

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NO therapeutic law has been more firmly established than that which has made immobilization obligatory for every joint injury, from the mild to the most severe. Nevertheless we all know its consequences; muscular atrophy which is rapid for certain muscles such as the femoral quadriceps, and stiffness of the joint. Also we know that such complications when once established are extremely tenacious and that frequently they do not yield completely to varied and very prolonged physiotherapeutic treatment. Even in the more fortunate cases it is necessary to continue such treatments for some months before getting the required results. Immobilization has been considered a necessary evil. It alone was believed to be capable of stilling the pains and obviating aggravation of the lesions, of preventing irritations and inflammations. In the case of purulent arthritis there was the stronger reason for carefully placing the joint at rest in order to avoid "dispersion of the germs" and extension of the infection.

It must, however, be recognized that in recent years there has been a mild reaction against systematic and prolonged immobilization. Many surgeons are now of opinion that for non-infected articular lesion at least, the joint ought be mobilized "as soon as possible." Although vague, this phrase is significant and shows a certain evolution of ideas produced by the force of events.

It is now some years since my attention was directed to this problem, and I have freed myself by degrees from practicing the law of immobilization. I commenced with evacuatory punctures to drain traumatic effusions of the knee, hemarthroses and hydarthroses, and by making the patient walk immediately. Not only could they do this without any difficulty but their lesion cured in a few days without leaving any trace. My method of treating traumatic effusions by puncture followed by immediate movement was rapidly adopted by practitioners dealing with industrial accidents owing to the rapidity and perfection of the recovery and also owing to its great simplicity.

Since the war the great frequency and infinite variety of articular lesions gave me the opportunity of applying this new method on a large scale. In the simplest and most severe conditions I have used immediate active mobilization after the operations for penetrating joint wounds with or without an included projectile, and for all varieties of intra-articular war fractures. I have not confined myself to non-infected fresh cases. I have also treated cases of purulent arthritis and it is perhaps in these difficult infected cases that the method has given the most astonishing success. But the object pursued differs. In simple lesions immediate active mobilization obviates atrophy and ankylosis. In purulent arthritis it seeks on the contrary to drain the articulations. In the first case the joint must be completely closed; in the second it must be left widely open.

A word as to the technique. It is practically the same whether the wound is aseptic or infected. In the case of recent injuries we commence by excising the soft parts of the wound, proceeding with the eventual esquillectomy of the fracture area, extracting projectiles and hermetically closing the joint. In purulent arthritis on the contrary; we must first execute an arthrotomy and leave the wound largely open. But starting from this movement we always proceed in the same way for mobilization.

The expression "immediate active mobilization" must be taken in its literal sense. The mobilization must be *active*, that is to say, made by the patient himself by muscular contractions. The movements ought reproduce the essential normal movements: ex-

tension, flexion, and rotation. The goal to be reached is to restore the physiological function of the articulation as much as possible, and in the case of the knee this function is walking. When complete functional restoration is not immediately possible, for instance in case of very extensive fracture, we must be contented with causing the chief active movements to be executed with the patient lying down.

Active mobilization cannot in any way be replaced by a *passive* mobilization, which does not call into play either the muscles of the limb or its nutrition, and which tends to restore mobility alone.

Mobilization must also be *immediate*, that is, commenced as soon as the patient awakens from anæsthesia. The patient must not be permitted to rest. The movements must be pushed to the maximum in every direction and must be kept up, so to speak, uninterruptedly. The treatment requires from the patient an effort which he will only make if he is kept at it all the time. He, therefore, needs supervision by a personnel in touch with the necessities of the treatment.

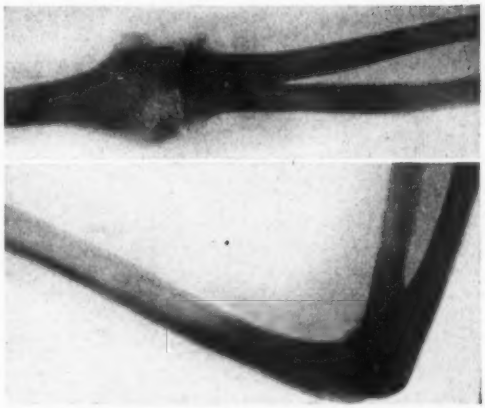
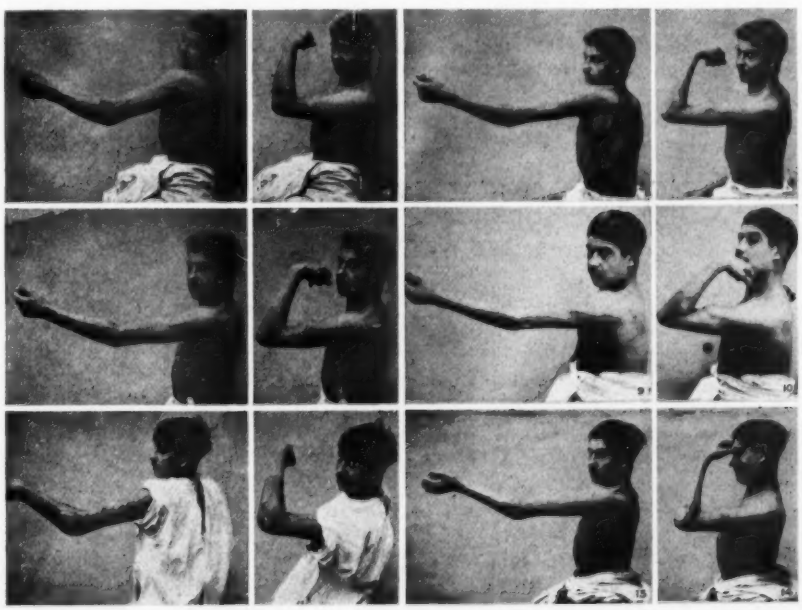


Fig. 1. Case 1. Roentgenogram taken on admission. Penetrating wound of left elbow by bullet with fracture of coronoid process. Purulent arthritis.
Fig. 2. Same as Fig. 1.



Figs. 3 and 4. Case 1. Two days after arthrotomy.
Figs. 5 and 6. Thirteen days after arthrotomy.
Figs. 7 and 8. Twenty days after arthrotomy.
Figs. 9 and 10. One month after arthrotomy.

Figs. 11 and 12. Two months after receipt of wound, 15 days after beginning of infection.
Figs. 13 and 14. Two months and a half after infection.

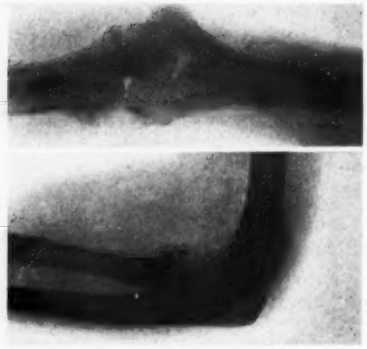


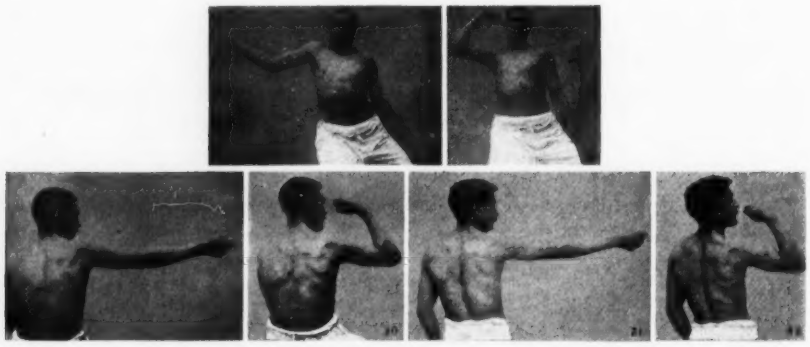
Fig. 15. Case 2. Compound fracture of external face of elbow by piece of grenade. Purulent arthritis. Roentgenogram taken on admission.
Fig. 16. Same as Fig. 15.

Active mobilization is always possible. It becomes more or less easy according to the extent of the lesions, the courage of the patient, and his aptitude in directing his efforts to the muscles which must be contracted and not wasting his strength in contracting other muscles than those necessary. Movements become easy according as they are repeated.

Active mobilization is not painful in the true sense of the term, except when it displaces large bone fragments and in such a case it is contra-indicated. But the movements are laborious and call for effort. It is found that a patient treated by active mobilization uses his limb in a variety of non-prescribed ways which he would not employ if the movements were painful. Many have stated that when a little pain is felt in periods of rest the best way of stopping it is to resume the movements.

Active mobilization gives the most surprising results in purulent arthritis. I do not hesitate to assert that against this formidable infection the new method is more efficacious than any of the means hitherto at our disposal.

In applying mobilization to the treatment of articular suppurations, my chief aim was to realize a satisfactory drainage after arthrotomy. We know that efficacious drainage of a joint by the ordinary means is an utopia. No kind of tube, no system of tampons, no means of irrigation, obviates retention nor stops the progress of infection. And it is on account of this insufficiency of drainage that arthrotomy has been almost abandoned and replaced by resection. But I have always been under the impression that to resect for the purpose of drainage alone is to go too far; and I have endeavored to empty the joint by expression, thanks to active movements. My earliest attempts convinced me. When a suppurated articulation has been opened by a large uni- or bilateral arthrotomy (a U-arthrotomy is never necessary) this is what is observed: At each extension and at each flexion the synovial surfaces are forced together by muscular contraction and pus is



Figs. 17 and 18. Case 2. Extent of movements during infection.
Figs. 19 and 20. Movements before the complete closure.
Figs. 21 and 22. Movements seven months after receipt of wound.

expressed often in the form of a jet. When the movements are very extensive and the muscles contract more vigorously the expression of pus is so much the more complete. If the movements are repeated a sufficient number of times the secretions are eliminated in accordance with the movements, retention is prevented, and articular drainage profoundly influences the local and general conditions. Locally, suppuration evolves like an ordinary abscess, but slowly. It lasts for a few weeks, abundant at first, then less, and finally disappears completely. During this period the arthrotomy opening or openings cicatrize. A species of fistula persists which closes from time to time and must be periodically opened. Œdema of the peri-articular tissues diminishes very rapidly and the tissues remain supple. Peri-articular abscesses are, so to speak, unknown.

With regard to the general state it is rapidly modified. From the commencement of active mobilization fever falls, not completely, as the patient may show 38° C. for some time. But the feverish aspect disappears; such patients do not look like badly infected cases.

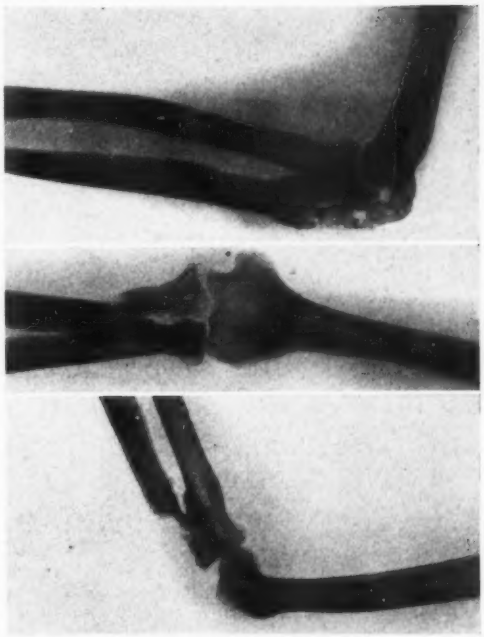
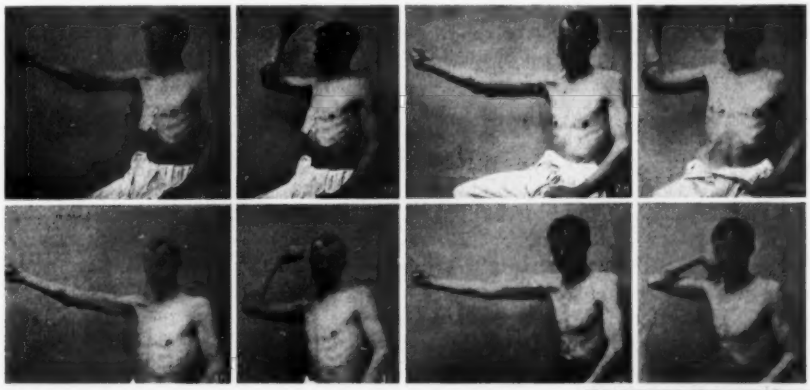
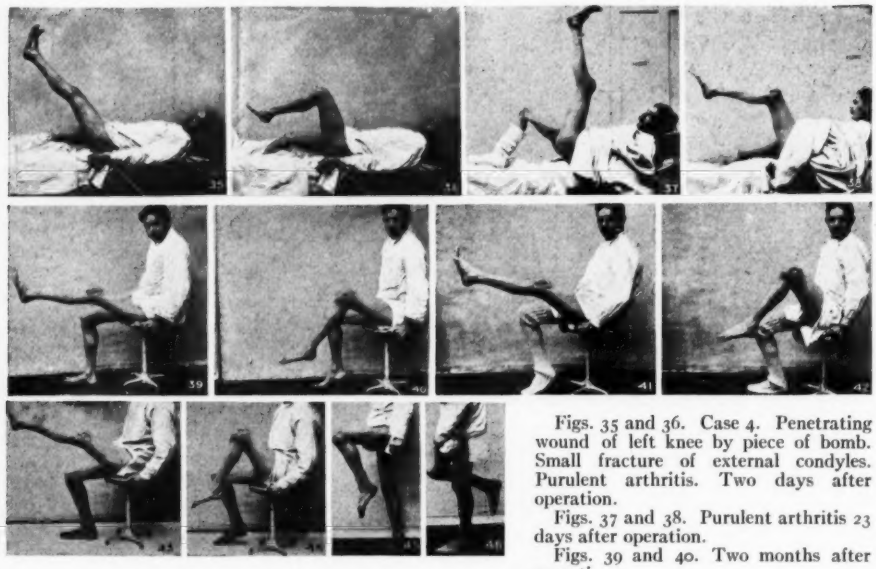


Fig. 23. Case 3. Compound fracture of olecranon and fracture of lower part of ulna; taken on admission.
Figs. 24 and 25. Case 3. After esquillectomy.



Figs. 26 and 27. Case 3. Two days after operation.
Figs. 28 and 29. Six days after operation, showing beginning of infection.
Figs. 30 and 31. Ten days after operation. Purulent arthritis.
Figs. 32 and 33. Four months after operation.
Fig. 34. Six and one-half months after operation.



Figs. 35 and 36. Case 4. Penetrating wound of left knee by piece of bomb. Small fracture of external condyles. Purulent arthritis. Two days after operation.

Figs. 37 and 38. Purulent arthritis 23 days after operation.

Figs. 39 and 40. Two months after operation.

Figs. 41 and 42. Two and one-half months after operation.

Figs. 43 and 44. Three months after operation. Figs. 45 and 46. Four months after operation.

Drainage is therefore realized in an ideal manner without a tube, and without irrigation of any kind. I am of the opinion that irrigations are more harmful than useful.

Drainage was my aim at first. But I obtained more. I have obtained preservation of the articular mobility. Unquestionably we must consider the recovery of a purulent arthritis with ankylosis as satisfactory, and be thankful that the patient has escaped resection; but it is evident that a mobile joint is much better than the best kind of ankylosis.

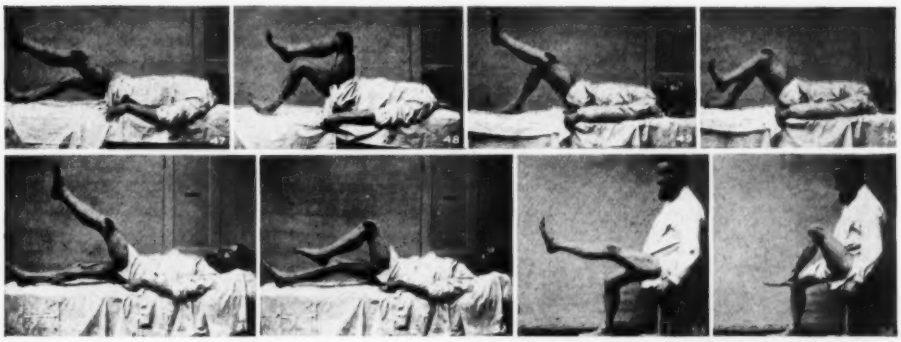
Owing to the movements the arthritis has but little effect on the musculature. The quadriceps, which rapidly atrophies in purulent arthritis of the knee, remains astonishingly vigorous; and in the final reckoning there is but a negligible degree of atrophy.

Preservation of the articular mobility seems due to the fact that the perfect drainage limits infection to the synovia alone and prevents its propagation to the cartilage and bone. This is what is observed.

If the procedure is followed in the manner indicated, mobility of the joint will always be preserved. From the moment that suppuration notably diminishes we sometimes see a tendency to stiffness. This is why I now partially and progressively close the arthrotomy wounds from this moment, and only leave such opening as is strictly necessary for the discharge of pus which is still forming. Proceeding in this way, mobility will be perfect and absolutely normal in the great majority of cases, no matter what the causative microbe may be. The limb will show no functional disturbance after an infection as terrible as purulent arthritis was formerly considered.

In my earlier cases there remained sometimes a slight defect in flexion or extension. But I have the impression that according as one becomes familiar with the method we more and more regularly obtain complete successes.

In purulent arthritis still more than in non-infected lesions it is difficult to realize the possibilities of active mobilization. It is so contrary to classical ideas that we must see the patients move their limbs in order to understand. The truth is that movements are perfectly possible in purulent arthritis treated



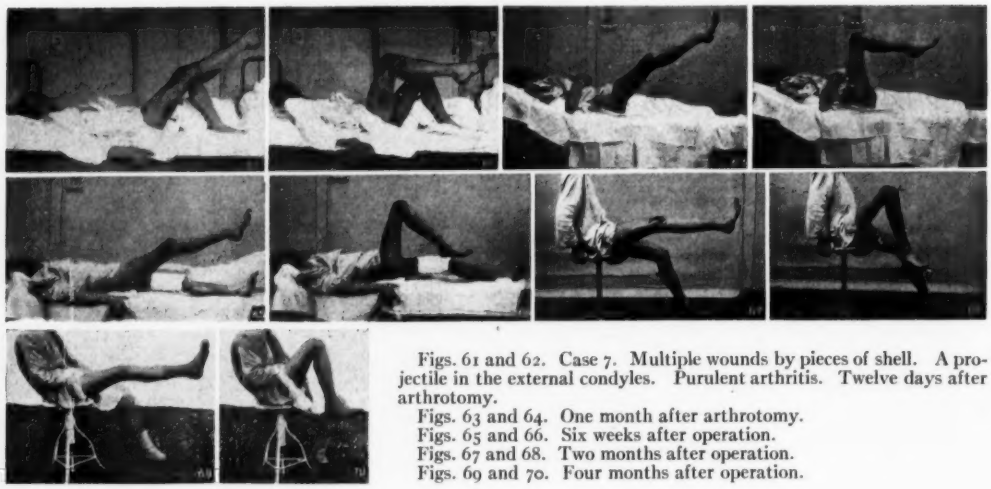
Figs. 47 and 48. Case 5. Multiple wounds by pieces of shell. Purulent arthritis of left knee from a small wound in the popliteal hollow. Twenty-five days after receipt of wound, 2 days after arthrotomy.
Figs. 49 and 50. Seven days after arthrotomy.
Figs. 51 and 52. Thirteen days after arthrotomy.
Figs. 53 and 54. Twenty-five days after arthrotomy.
Figs. 55 and 56. Six weeks after arthrotomy.

by arthrotomy, to the same extent as in non-infected articular lesions treated by excision of the damaged tissues and total primary suture. Movements are no more painful in the first case than in the second. They are equally laborious in the two cases. True pain appears only when the drainage is insufficient; and then it becomes necessary to drain more completely to cause an immediate cessation of pain. Whenever a patient complains of pain, especially in the popliteal space, it is almost certain that there is retention. The patients themselves soon learn to recognize this cause of pain and stop it by means of some movements.

In order to be convinced that movements are not painful, there is nothing better than to observe a patient when he does not know he is being watched. It is then seen that far from fearing movements, as was the case with the classic treatments, he constantly moves the joint without apparently being concerned about it, or preoccupied with the position of the limb. This fact, easily verified, proved quite clearly that if the articulations were even feebly painful, the patient would instinctively keep the part at rest.

Patients with purulent arthritis of the knee can walk early, even before cicatrization of the arthrotomy wound. It is the same with purulent tibiotarsal arthritis. It is a curious experience to see them walk with the joint widely open, expelling a little pus at each step.

Figs. 57 and 58. Case 6. Multiple wounds of both legs and eyes by pieces of grenade. Penetrating wound of left knee. Purulent arthritis. Three weeks after arthrotomy.
Figs. 59 and 60. Four months after arthrotomy.



Figs. 61 and 62. Case 7. Multiple wounds by pieces of shell. A projectile in the external condyles. Purulent arthritis. Twelve days after arthrotomy.
Figs. 63 and 64. One month after arthrotomy.
Figs. 65 and 66. Six weeks after operation.
Figs. 67 and 68. Two months after operation.
Figs. 69 and 70. Four months after operation.

With regard to the question whether immediate active mobilization is applicable to cases in which purulent arthritis accompanies an intra-articular fracture, it can be answered affirmatively. As in non-infected lesions mobilization can be effected in purulent arthritis with fracture on condition that there is no fear of displacing the fragments. If there is, movements are contra-indicated because they might dislocate the joint.

A second circumstance which renders this method inapplicable is primary destruction of the ligaments and of the articular capsule. When the means of union have disappeared it is evident that the joint can no longer be mobilized by muscular contraction. But it is well to know that a partial destruction of the means of union does not render the method quite inapplicable.

I give here the history of some cases of purulent arthritis of the elbow, knee, and instep, due either to the diplococcus, staphylococcus or the streptococcus, with or without intra-articular fracture. These have been treated by simple arthrotomy followed by immediate active mobilization without any other means of drainage and without lavage. In all these patients drainage has been perfect, the temperature has not been high, the general state has remained excellent, infection has been confined to the synovia, there has been little or no atrophy, and articular mobility has been intregrally preserved.

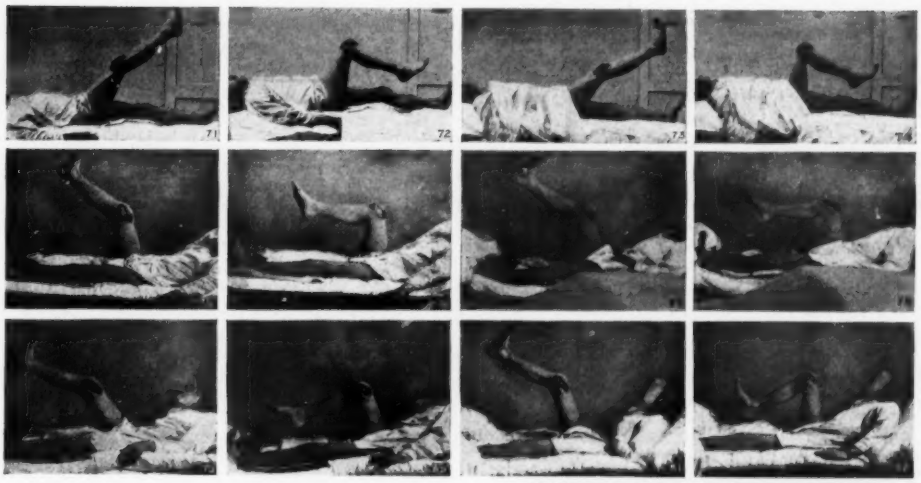
Case 1. Van D., Auguste. Perforating gunshot wound of the left elbow with comminutive fracture of the coronoid process. Bilateral arthrotomy with clearance, and excision of soft parts. Total closure of the two wounds.

The patient began to move his elbow two hours after operation. After a week extension and flexion were effected without difficulty and in a wide extent. Recovery continued and the movements became almost normal; then toward the seventh week, after an accidental torsion of the elbow, hemarthrosis was produced, then peri-articular abscess, and finally a purulent arthritis. An external arthrotomy was done. Pus showed staphylococci.

Movements were continued without interruption; they soon resumed their primary extent which had been much reduced owing to the infection. One month after the arthrotomy, the secretion was clear. The wound had been partly closed after 18 days. Two and a half months after infection the movements became very extended. There still persists some thickening of the epiphyses (Figs. 1 to 14).

Case 2. L., Alphonse. Grenade wound of the external face of the right elbow. Loss of substance of external condyle and of the cupula of the radius. No projectile included.

Excision of the musculocutaneous wound. Ablation of fragments. Total closure. Active immediate mobilization. Redness and swelling the following day. Wound reopened. Movements continued and serosanguineous fluid expressed. On the next day the fluid was purulent. Staphylococci. Movement continued without much difficulty and extended. Temperature did not exceed 38.4°.



Figs. 71 and 72. Case 8. A piece of shell in the right knee with fracture of the tibial epiphysis. Purulent arthritis. Twelve hours after arthrotomy.
Figs. 72 and 73. Three days after operation.
Figs. 74 and 75. Fifteen days after operation.
Figs. 77 and 78. One month after operation.
Figs. 79 and 80. Six weeks after operation.
Figs. 81 and 82. Two months after operation.
Figs. 83 and 84. Case 9. Compound fracture of peroneus by piece of shell. Infection. Purulent arthritis. Three months after operation.

After a month, without any irrigations, secretion was reduced to a minimum, and the wound began to close. The extent of the movements increased each day, and they were easily accomplished, although they were more difficult after the night's rest. It required 4 months for definite closure of the wound. At present all movements are complete. The musculature is superb (Figs. 15 to 22).

Case 3. R., Victor. Right elbow traversed by piece of bomb. Olecranon shattered and comminutive fracture of cubitus.

External arthrotomy. Complete clearance; the whole olecranon removed. Ether lavage of joint and complete closure. Immediate active mobilization which the patient does very well. By the third day a right angle of flexion was reached with complete extension. But by the sixth day there was swelling and redness and the movements diminished. Then some pus squirted between the sutures. Wound reopened. Movements continued without interruption with very complete expression of pus. No fever and the general state excellent. Streptococci in pus. Cicatrization after 3½ months of suppuration. The definite results showed that movements of the elbow are intact and the muscles in excellent state (Figs. 23 to 34).

Case 4. Z., Henri. Penetrating bomb wound of left knee. The projectile entered the external side of the knee through the articulation producing a comminutive fracture of the external condyle and lodged higher up in the femur.

External lateral arthrotomy. Excision of soft parts, clearance of the bone area, total closure. Immediate active mobilization. From the second day flexion reached a right angle and extension was complete. There was a heavy hemarthrosis discharging between the sutures during movements. On the sixth day the temperature increased; the knee swelled and became painful; movements were less extensive. Arthrotomy wound reopened. Discharge of a large quantity of thick pus. Wound was left open and movements continued. In the pus large numbers of small diplococci and staphylococci were found. During the following days the discharge being insufficient an internal arthrotomy was added. From this on the drainage was good and the movements increased in amplitude.

After 4 weeks the secretion took a serous aspect and notably diminished. The two wounds were partly closed. The remaining part of the external wound closed very rapidly and did not reopen.

Examination 4½ months after injury shows walking absolutely normal, integral mobility and the muscles in excellent state (Figs. 35 to 46).

Case 5. H., Louis. Multiple shell wound of the limbs and abdominal wall. A projectile deeply em-

bedded in the popliteal space, which had passed unnoticed, set up a purulent arthritis of the knee 3 weeks after entrance.

Bilateral arthrotomy. Immediate active mobilization. The pus contained diplococci. Two days after the arthrotomy flexion reached a right angle and extension was complete. Toward the seventh week suppuration having much diminished the arthrotomy wounds were partly closed. Cicatrization terminated 2½ months after the arthrotomy. The knee function is absolutely normal and the musculture intact (Figs. 47 to 56).

CASE 6. R., Romain. Multiple grenade wounds of the limbs and the two eyes. Penetrative wound of the left knee. General state at entrance too bad to permit an immediate operation. External arthrotomy of the left knee the next day. Ablation of a large intra-articular piece of projectile and a piece of cartilage embedded in the soft periarticular parts.

Total closure. Immediate active mobilization. Movements were good, but progressive tumefaction of the articulation followed, with pain; temperature, and gush of pus between the sutures.

The arthrotomy wound was reopened giving issue to a seropurulent fluid containing numerous diplococci. Movements continued. Evacuation of the fluid being incomplete, an internal arthrotomy was added and the knee drained more completely.

The first attempt at suture made when the flow diminished did not hold. A second suture held partly. During all this time the movements were continued.

As the suppuration cleared the remaining part of the wound closed. At the end of 4 months, after partial retentions, which each time necessitated large opening of the wound, complete recovery was obtained with absolute integrity of the muscles and of the articular mobility (Figs. 57 to 60).

CASE 7. G., Leonard. Penetrating shell wound of the right knee. Projectile embedded in the external condyle and cartilaginous covering of the condyle torn. Large muscular wound of calf and popliteal space communicating with the joint.

Multiple wounds.

External arthrotomy. Ablation of projectile. Curetting of bone parts. Total closure and immediate active mobilization.

The next day movements were well executed. But gaseous gangrene, invaded the wound of the calf and popliteal space. The joint, although communicating with this wound was then re-opened with an abundant flow of purulent serosity containing staphylococci, diplococci and some rod-like bacilli.

CASE 8. D., Albert. Shell wound of right knee. Projectile embedded in tibial plateau pushing into the articulation.

The suppuration continued abundant for several weeks. Movements were continued without interruption and became more and more extensive in spite of great apathy on the patient's part. At intervals there was retention with immediate diminution of mobility and rise in temperature.

After 4 months, the arthrotomy wounds, which had been partly sutured, were almost cicatrized. Movements were integrally preserved and the muscles remain in excellent state (Figs. 61 to 70).

Operated upon 15 hours after injury. External arthrotomy. Evacuation of a large quantity of seropurulent fluid. Ablation of projectile; owing to time elapsed since injury wound is left largely open.

Mobilization was commenced 4 hours after operation. Flexion to right angle. Complete extension Fluid found sterile at first. The next day it contained staphylococci. After some days, the pus being very thick and the evacuation being insufficent, an internal arthrotomy was added. Streptococci were now found in the pus.

Abundant suppuration persisted 3 months; then subsided. During all this time movements were easy and extended, except when there was some retention, always attended by pain, temperature, and diminution of mobility.

At present moment cicatrization is not yet complete. There are still some streptococci. Articular moblization is perfect and the musculature is in excellent condition (Figs. 71 to 82).

CASE 9. M., Joseph. Shell wound of left leg with comminutive fracture of fibula, cleansing and scrupulous clearing of fracture area. Infection of wound. Abundant suppuration. Purulent tracts toward the foot.

Five weeks after injury the infection spread to the tibiotarsal articulation. Staphylococcic purulent arthritis. External arthrotomy. Wound left completely open. Immediate active mobilization.

During 8 to 10 days the articular suppuration was abundant and temperature remained high. Then the secretion began to diminish as well as the fever.

At present, 3 months after injury and about 2 months after the beginning of the purulent arthritis, the wound is cicatrized. The movements and the musculature are normal (Figs. 83 and 84).

ROENTGENOGRAPHIC DIAGNOSIS IN RENAL TUBERCULOSIS[1]

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SEVERAL articles have appeared in European literature in recent years concerning the value of roentgenographic findings in the diagnosis of renal tuberculosis. Probably the most comprehensive of these is one written by Burchard who has made a thorough review of previous literature on the subject. In this country the method has had only limited use, and its importance does not seem to have been appreciated by American observers. Articles referring to the subject have been published by Krotoszyner and by one of the writers (Braasch).

The roentgenographic data in renal tuberculosis are regarded of such importance at the Mayo Clinic that it is a rule to make a complete roentgenographic examination of the urinary tract in every case in which renal tuberculosis is suspected. The frequency with which positive data may be obtained in the roentgenogram is evidenced by the fact that in the years 1916 and 1917, 131 patients were operated on for renal tuberculosis, and roentgenographic examination of the urinary tract had been made of all. Of this number positive shadows suggestive of renal tuberculosis were found in thirty patients, a percentage of 22. It may be stated, therefore, that approximately one out of five patients with renal tuberculosis will have positive roentgenographic data of definite diagnostic value. Such data are of particular value in conditions as follows:

1. When, because of the contracted condition of the bladder or impassable stricture of the ureter, the cystoscopic findings are inadequate.

2. When the cystoscopic findings are not typical of renal tuberculosis.

3. When the clinical findings are not suggestive of renal tuberculosis or of any involvement of the urinary tract, as may occur with a closed tuberculous pyonephrosis.

4. In the presence of bilateral renal tuberculosis when the typical shadows frequently render cystoscopy or further clinical examination unnecessary.

The roentgenographic shadows are caused by the deposit of calcium in the tuberculous area and may assume a variety of forms. To one who has had considerable experience in roentgenographic interpretation, such shadows will have characteristics that are usually recognized. They may be differentiated from a stone shadow by (1) the variability in its density, as the shadow is irregularly concentrated in different portions, (2) by a shadow of lesser density throughout than that usually observed with stone, and (3) by its irregular and indefinite outline. The calcareous area may, however, simulate the shadow of a renal stone in every particular, and it may be quite impossible to differentiate it without further clinical data. The same is true of renal stones that are occasionally seen of such consistency that the shadow will be fully as irregular and hazy in outline as a typical tuberculous shadow. It may be said, however, that approximately 75 per cent of tuberculous renal shadows may be recognized as such in the roentgenogram.

On resection of the kidney, an examination of the areas casting shadows in the roentgenogram will show a considerable variability in the nature of the calcareous deposit. Usually two definite types are recognizable, namely, actual deposits of lime encrusting the ends of the calyces, and caseated areas containing a sufficient deposit of calcium to cast a shadow. Tuberculous shadows may be roughly classified under three groups: (1) multiple scattered small areas, (2) single or a few localized areas of one centimeter or more in diameter, and (3) large irregular, diffuse areas involving either a large portion or the entire kidney.

In the first group the small scattered areas are generally caused by lime deposits. They are occasionally seen singly, and appear as elongated, irregular faint streaks, or as multiple punctate areas, scattered over a large portion of the kidney, usually in one of

[1] Paper presented before the Chicago Urological Society, Chicago, April, 1918.

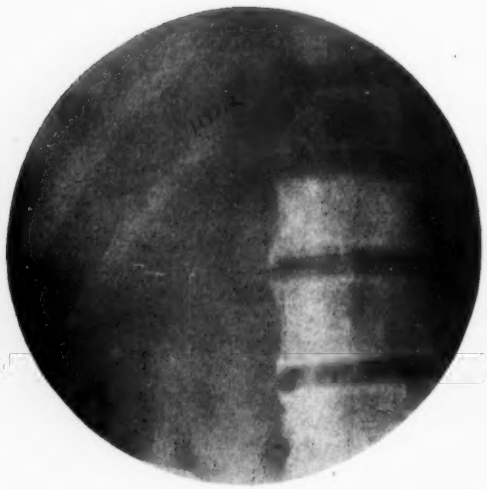

Fig. 1. Shadows in Group 1 which consist of multiple small calcified areas in the lower pole of the kidney.

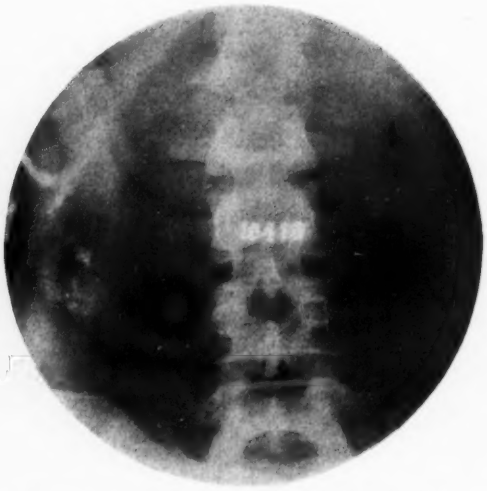

Fig. 2. Several calcified areas of larger size with some characteristics of Group 2.

the poles. Unless the renal area in the roentgenogram is carefully examined such areas may easily be overlooked.

The second group representing single or several isolated areas of concentrated calcareous deposit is the type most easily confused with stone. The shadows are usually of several varieties: (1) a shadow of irregular outline with a consistency dimmer than that seen with renal stone and varying in size from 1 to 3 or 4 centimeters; (2) a shadow characterized by great irregularity in its consistency and outline, somewhat resembling filigree work; and (3) definite shadows with a density and contour suggestive of stone. The size of the shadow in no way indicates the extent of the tuberculous lesion. A shadow of only a centimeter or two in diameter may be present in a tuberculous lesion involving the entire pole or even the complete kidney.

The third group is characterized by large, regular rounded shadows of variable density in their various portions. As a rule, on section, the kidney is of a putty-like consistency in the area which causes the shadow. It is, however, impossible to say from the appearance of such caseated areas whether or not a shadow will be present in the roentgenogram. In two caseated areas of similar appearance one may cast a shadow and the other none at all. Occasionally the calcium deposit is so slight that a soft diffuse shadow will be seen only on careful plate reading, and it may be easily confused with similar shadows cast by the bowel.

Shadows caused by complete caseation of the kidney are most striking. They may assume the outline of a complete cast of the kidney and are usually irregularly lobulated. The shadow may vary in density in different portions of the kidney, some of which may be so dim as to be scarcely discernible while others may be definitely and strikingly outlined. Occasionally, with complete or extensive calcification, the calcium deposit may be so slight that the X-ray simulates that of accentuated normal renal outline, and it may be difficult to determine whether or not it is an actual pathologic shadow.

Actual renal stone formation is rare in tuberculous kidney. When it does occur it is generally a phosphatic stone, formed in a localized abscess with necrosis and secondary infection. We have observed this in several cases. Stone formation in the opposite kidney in cases in which a tuberculous kidney had been removed occurred in but two instances that came under our observation. One patient

Fig. 3. Single large calcified area in the lower pole of the kidney which belongs to Group 2, suggestive of renal stone.

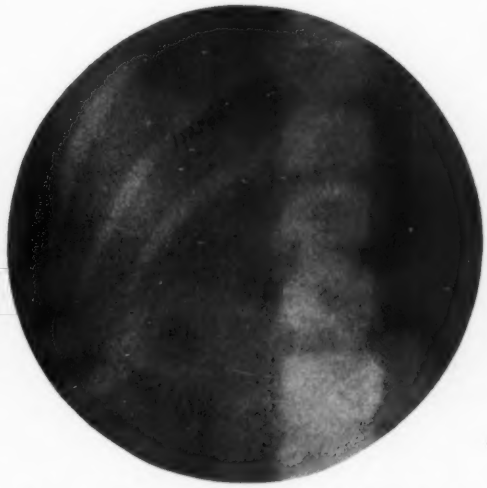

Fig. 4. Typical "filigree" shadow belonging to Group 2.

passed a small renal calculus from his remaining kidney two years after the other kidney had been removed for tuberculosis. It may be inferred that primary stone formation is unusual in patients with renal tuberculosis.

Extrarenal shadows. Calcareous deposits of the kidney may be confused with renal stone. They must also be differentiated from various extrarenal shadows which frequently appear in the roentgenogram. The most common cause of confusion is the deposits in glands situated in the perirenal tissues. Calcified tissues situated in the pleura, subdiaphragmatic and retroperitoneal areas are especially likely to cast shadows closely simulating intrarenal calcification. Next to be considered is the possible confusion of shadows caused by substances in the bowel. These may be readily identified, however, by disappearance or change in position while subsequent roentgenograms are being made. Gall-stones may also occasionally cast a shadow which will closely simulate renal tuberculosis.

Ureteral shadow. Calcareous deposit may occur with tuberculosis in the ureter, although less frequently than in the kidney. When it is present a considerable portion of the ureter, usually the lower portion, is involved. The shadow may be several centimeters or more in length and outline the dilated ureter to a greater or less extent. The shadow is caused either by calcareous deposits in the thickened wall of the ureter or by intra-ureteral calcareous deposits. Such deposits are generally accompanied by similar caseation in the kidney. Considerable peri-ureteritis may accompany this calcification of the ureteral wall. The peri-ureteral infiltration together with the thickened ureter will often cause a tumor-mass which can easily be palpated on rectal or vaginal examination. Often calcified glands in the bony pelvis will cast shadows suggestive of either stone or tuberculous deposit in the lower ureter. They, however, usually occur with no clinical evidence of tuberculosis in the urinary tract or other portions of the body, and are therefore of no diagnostic significance.

Calcareous deposits in the prostate gland. Occasionally calcium deposits secondary to tuberculosis in the prostate gland cause roentgenographic shadows suggestive of prostatic stone. Although the clinical findings should differentiate the two conditions, a chronic healed tuberculous infection may be overlooked.

Renal outline. Interpretation of the outline of the kidney itself in the roentgenogram is

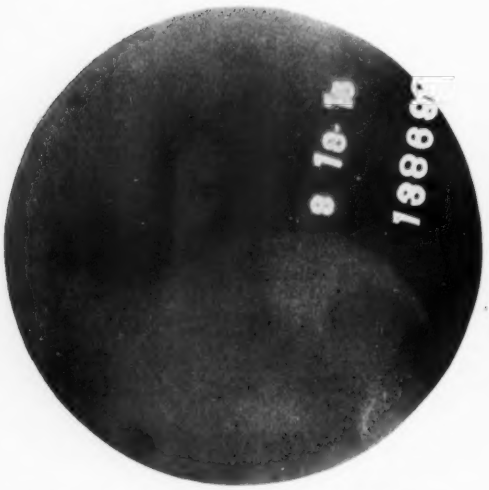

Fig. 5. Two areas of calcification of the lower pole with shadows suggestive of stone, Group 2.

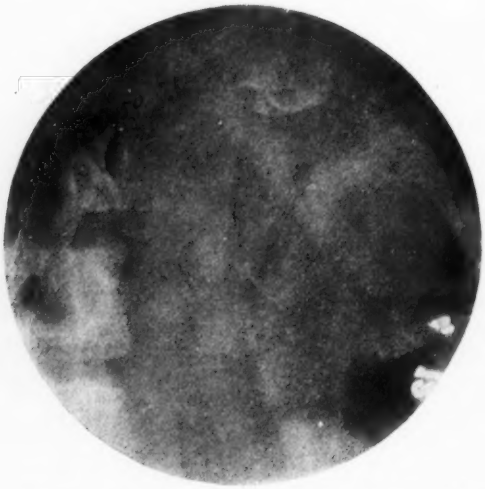

Fig. 6. Irregular calcified area in the upper pole of the kidney easily confused with calcified tissues in the pleura.

not of much practical value. Some observers have claimed that irregularity of outline of a tuberculous kidney may be demonstrated in the unaided roentgenogram. However, the possibilities of error are so great that these data are not to be relied on. It is well-known that bowel contents, the outline of surrounding organs, change in position of the kidney, etc., cause factors which interfere seriously with accurate interpretation of the renal outline. Occasionally, as Casper has stated, the outline of a greatly hypertrophied kidney on the opposite side of a tuberculous shadow may be of value in indicating hypertrophy subsequent to destruction of the diseased kidney. However, one would be loath to remove a definitely tuberculous kidney without further proof to demonstrate that the hypertrophied kidney is otherwise normal.

Bilateral involvement. Roentgenographic evidence of renal tuberculosis may be of value in determining the existence of bilateral involvement or that the patient is otherwise inoperable. With shadows of definite tuberculous calcification present in both kidney areas, cystoscopic and further clinical investigation is usually unnecessary. It must be remembered, however, that bilateral renal tuberculosis may exist even though a tuberculous shadow may be found only in one kidney area. This is particularly true with a chronic tuberculous infection in one kidney, and a recent involvement of the other. If the bladder is in such a state that it is impossible to make a satisfactory cystoscopic examination, a shadow of calcification in one kidney area might be of considerable diagnostic value. This is illustrated in conditions as follows: (1) when the healthy kidney has been catheterized and it is impossible to find or catheterize the other side; (2) when neither meatus is found but the patient's general condition, and the renal functional tests indicate the existence of one healthy kidney; and (3) when evidence of disease is found in the kidney that is catheterized, and there is a shadow of calcification in the kidney which cannot be catheterized.

Pyelography. A common source of error in diagnosis is the confusion of shadows caused by renal stone and by tuberculosis. The clinical findings may be identical. At operation instead of finding the expected stone and performing a lithotomy the surgeon will be called on to do a nephrectomy for tuberculosis. Although the cystoscopic and laboratory findings will usually identify the tuberculous shadow occasionally they too, will fail.

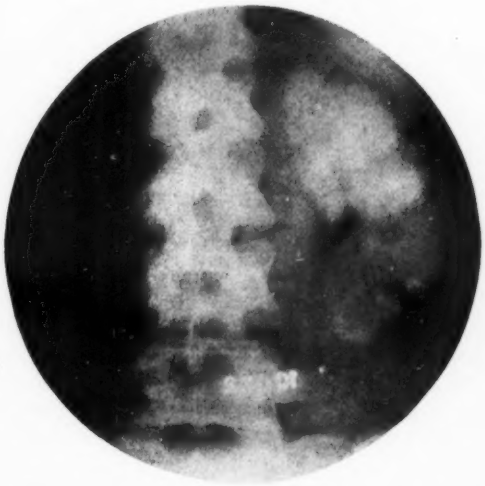

Fig. 7. Outline of a completely caseated kidney, Group 3.

Fig. 8. Calcified areas in both kidneys, a condition which is found in bilateral renal tuberculosis.

In the identification of such shadows, as well as of renal infection of a doubtful nature, pyelography will frequently afford valuable information by demonstrating the pathologic changes in the pelvic and ureteral outline peculiar to tuberculosis.

The changes in the pelvic outline regarded as characteristic of tuberculosis consist of one or more of the following: (1) irregular inflammatory dilatation of the pelvis, (2) areas of cortical necrosis, and (3) stricture in the ureter.

Inflammatory dilatation of the pelvis as the result of tuberculosis in its early stages is largely confined to the calyces. The dilatation is differentiated from ordinary inflammatory dilatation by the greater irregularity in outline of the calyces and by the variability of degree of dilatation among the different calyces. A peculiarity often noted is marked dilatation at the uretero-pelvic juncture.

When the process is advanced, so as to cause necrosis of the renal parenchyma adjacent to the calyces, the pelvic outline becomes irregular and indistinct to a variable degree. When the necrotic areas are confined to one or two calyces the outline of the latter will have a moth-eaten appearance at the apices, and the pyelographic medium is visible as a hazy shadow extending into the parenchyma. When the necrotic process is advanced, it may either assume irregular forms scattered through the parenchyma or it may coalesce to form a large irregular sac.

Occasionally the outline of the necrotic area is apparently detached from the pelvis,

Fig. 9. Calcification of the lower portion of a tuberculous ureter.

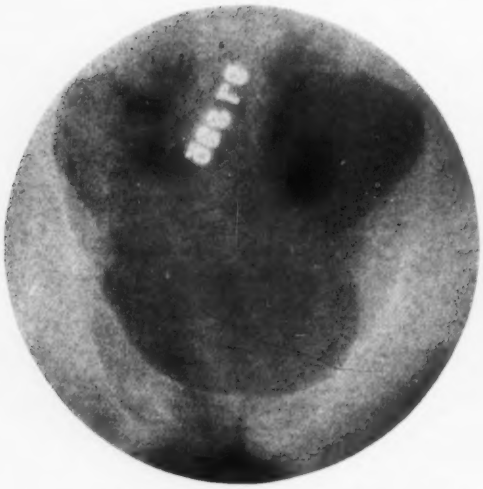

Fig. 10. Calcification of tuberculosis which occurs in the prostatic gland.

Fig. 11. Pyelogram showing inflammatory dilatation and necrosis of calyces, which occurs in tuberculosis.

or connected with it by a narrow isthmus. When the area of necrosis is confined largely to the cortex and is not directly communicating with the pelvis, the pelvic outline may occasionally become contracted in a manner resembling certain forms of pyelonephritis.

As a result of the infective process in the kidney, inflammatory dilatation of the ureter will follow and may be demonstrated in the ureterogram. Should the ureteral mucosa become ulcerated, however, and a stricture ensue, mechanical dilatation may also be present. Ureteral dilatation resulting from tuberculous stricture in the ureter may be confused with that resulting from a benign stricture, or obscure lithiasis. If the clinical and cystoscopic findings are insufficient with which to identify the lesion, pyelography will usually demonstrate abnormality in the pelvic outline that is suggestive of tuberculosis.

The cystogram may also occasionally be of diagnostic value. This is particularly true when it is impossible to find either one or both meatus. The bladder outline will be variably contracted and usually more in one half of the bladder. The demonstration of a dilated ureter by making a cystogram with the patient in the Trendelenburg position is suggestive of renal involvement on that side. Demonstration of a widely dilated internal bladder sphincter and posterior urethra in the presence of a severe cystitis is also suggestive of tuberculosis.

CONCLUSIONS

1. The value of roentgenographic diagnosis of renal tuberculosis does not appear to be fully appreciated.

2. Routine roentgenography in every case in which there is evidence of infection in the urinary tract is adviasble.

3. Shadows may be found in approximately 20 per cent of patients with renal tuberculosis. Such shadows may require the aid of cystoscopic data in their interpretation.

4. Positive evidence of tuberculosis may be obtained by this method when all other clinical data fail, and when cystoscopic examination is impossible.

5. Shadows due to renal tuberculosis may be arranged into three definite groups.

6. Caseated areas in the ureter and prostate may also be outlined.

7. Pyelography is occasionally valuable (1) in the identification of renal infections of doubtful nature and (2) in the identification of doubtful shadows in the renal area.

8. The cystogram may also give data of value (Figs. 1–11).

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ACUTE INTESTINAL OBSTRUCTION FOLLOWING APPENDECTOMY

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DESPITE the development of greater proficiency, postoperative intestinal obstruction occurs sufficiently often to warrant occasional discussion. Acute intestinal obstruction, secondary to appendectomy, is one phase of the general topic demanding critical attention, as to the manner of causation and production. It is a demonstration that the last word has not been said concerning appendicitis, despite the voluminous literature existing on the subject, a fact evident to those engaged in active surgical service, where the mortality of acute appendicitis is still a matter of serious concern.

The special point in the discussion is the prevention of the condition. An analysis of the methods of treatment, merely detailing one aspect of the general subject of intestinal obstruction, would not permit so practical treatment of the question, as an investigation of the manner of production of the obstruction. It will not be necessary to analyze the personal cases herein reported regarding the special lesions produced in each instance for the specific causes can be obtained from a general reading of the literature. Certain distinct mechanisms, however, come to mind at once. I refer, particularly, to the rôle played by the omentum, and that taken by adhessions. The omentum, owing to its migratory nature in abdominal inflammation, may contract a firm adhesion to an organ, especially, the tube or uterus, producing, as a result, a sling or hammock over or beneath which an intestinal loop may be constricted. If the omentum is lax or loose, intestinal occlusion does not occur. On the other hand, if the omentum, from any cause becomes taut, for example, from elevation of the transverse colon or from a twist or torsion in the omentum itself, it acts as a tightly drawn string playing on the face of the intestinal loop. When the obstruction acts intermittently, there results, secondary to strangulation, transudation into the peritoneal cavity. An omental band, from anatomical reasons, is more likely to obstruct the small than the large intestine. A history of a previous abdominal operation adds a confusing element. Pelvic operations, performed at a period when peritonization of pedicles and raw surfaces was not generally practiced, furnish numerous instances of postoperative intestinal obstruction, due to bands, adhesions and false ligaments.

The artificial and experimental production of adhesions lends itself readily to a study of their prevention. A review of the histology of the peritoneum, however, fails to bring out any vital points. There exists, no doubt, a distinctive peculiarity of the mesothelial cell which favors its proliferation. Also, the lymphatic current of the peritoneum, of which so little is known, may be important. The tendency of the peritoneum to agglutinate, appears as a reaction to irritation.

physical or chemical. It is a primary and characteristic manifestation of a cell, and, in this instance, is an indication of a defensive mechanism. The mere presence of the operator's fingers may, occasionally, be sufficient to produce adhesions. On the other hand, a prolonged operation, with considerable handling and manipulation of the intestine, may occasion no essential change in the peritoneum. The extent of the infection appears negligible. A gangrenous appendicitis, associated with diffuse peritonitis, may lead to no discernible sequelæ; whereas, an interval appendectomy, with a minimum amount of peritoneal contact may rapidly produce proliferative changes and band formation.

There are individuals, in whom a tremendous degree of intestinal matting may exist, without the slightest personal discomfort or objective indication. In a young married woman, who came under my observation at St. Francis Hospital, I opened the abdomen with the intention of correcting a retroverted uterus, the main and sole symptoms being backache. At operation, there was found an intestinal matting and agglutination, almost indescribable in its complexity. In a word, it is evident there exist compensatory mechanisms which overcome the stenosing effects of these knots and twists. Doubtless, this is associated with the degree and vigor of the peristalsis, but the physiology of the intestinal movements is still, in many respects, a closed chapter.

In the past, the subject of postoperative obstruction has been largely discussed from the point of view of the effect of drainage. There is no question regarding the objectionable reaction of abdominal drainage. It is manifest that a foreign body left in the peritoneal cavity must inevitably act as an irritant. Not only its actual presence, but the respiratory movement of the abdominal wall and the peristaltic activity of the intestine, increase the deleterious consequences of the drain. This point having been unduly emphasized, has, perhaps, led surgeons to show a tendency to discard drainage, or, at least, to reduce it to a minimum. A few years ago, this practice became almost perilous in its consequences, when the custom to close the incision in acute gangrenous and acute suppurative appendicitis, with small amounts of exudate, became general. This was but a natural reaction from the principle of so-called sequestration, when large quantities of gauze were inserted surrounding the field of operation. The gauze was permitted to remain, letting the house surgeon assume the responsibility, and, incidentally, the censure for its removal. This method of drainage, aptly called taxidermy by a facile writer, has been discarded. The small cigarette drain, or split rubber tube, is now the usual method of drainage. It is easily improvised, and apparently, causes a minimum amount of peritoneal reaction. One cannot leave this phase of the question, however, without speaking a word in favor of gauze. There are distinctive types of cases in which gauze drainage is indispensable; I refer, specifically, to those in which the ligation of the meso-appendix is insecure or uncertain, or in which hæmorrhage has taken place during the delivery of the appendix. Moreover, gauze drainage is imperatively needed in the cases associated with impending gangrene or perforation of the cæcum. Through its capacity to stimulate adhesions, gauze tends to localize the infection.

The method employed of treatment of the stump — simple ligation or inversion — seems to be immaterial. One should attain a degree of asepsis extreme as possible. Any extraneous leakage favors the development of plastic adhesive peritonitis. When alcohol and carbolic acid are used to sterilize the stump, care is needed to prevent accidental contact of the solutions with the intestine. Naturally, in a case demanding drainage, the element of peritoneal irritation and reaction is uncontrollable. Here the sequelæ of band formation, intestinal matting and kinking are inevitable, as no method exists which entirely obviates these objectionable end-results.

A possible cause of adhesion formation is suggested in the widespread use of iodine in the preliminary sterilization of the field of operation. It is known, in fact, has been experimentally proved, that iodine is a peritoneal irritant. The intestine, particularly, the

small intestine, should not come in contact with the skin. I use dry laparotomy pads to wall off the appendix. They are more apt to maintain their position when spread out flat and do not crumple to form a ball-like mass. They preserve a dry field and absorb the pus and blood with greater ease and rapidity. There is experimental evidence which tends to demonstrate that laparotomy pads soaked in hot solution are less liable to create intestinal adhesion; but, as the formation of intestinal adhesions is not clearly understood, and subject to many interpretations, this theoretical objection may be overlooked.

The symptoms of acute intestinal obstruction are so well-known, that it is needless to repeat them. Of course, the type of obstruction considered here, is the purely mechanical or dynamic type, usually due to a band or kink. The most common form of postoperative obstruction is concomitant with the extension of the infection to the peritoneum. This produces the most intractable type of intestinal paralysis. The underlying pathology is evident. The wall of the intestine is saturated with the toxins and products of the bacteria. As a result, the local neuromuscular mechanisms are poisoned and paralyzed. The administration of powerful cathartics, under these circumstances, is not only useless but stupid. There is a rare type of obstruction, due to a functional paresis, or, perhaps, inhibition of the intestinal musculature. This type responds readily to liberal doses of pituitrin. Eserin salicylate, widely heralded at one time as a panacea, is an uncertain drug, and moreover, known to depress the circulation. I have seen several instances when death promptly followed its use. It has been stated that one of the most important signs of intestinal obstruction is the rise in the leucocyte count. In order to estimate properly the value of this sign, it would be necessary to have the blood examination before, and a daily count following, operation. In a busy hospital, this procedure is not feasible. Moreover, as the blood count is modified by so many factors incidental to an operation, as hæmorrhage and infection, its significance is susceptible to various interpretations. A bimanual examination aids in the diagnosis. It occasionally happens that an incarcerated or strangulated loop may fall or even lie in the pelvis. Bimanual examination then discloses a tense cystic swelling behind the posterior fornix.

Intestinal obstruction is rarely so sudden in onset as to mimic internal hæmorrhage. Yet an acute strangulation of an intestinal loop may cause shock and collapse so severe as to suggest the diagnosis of internal hæmorrhage. In a woman who had been operated on by a colleague for chronic appendicitis and salpingitis, strangulation was so sudden that severe shock took place at once and collapse rapidly supervened. The traditional symptoms of internal hæmorrhage were clearly simulated. Yet, at operation, I found no evidence of hæmorrhage. A loop of ileum was strangulated beneath a pelvic peritoneal band.

Acute obstruction of the small intestine, particularly, when the obstructing force acts intermittently, is insidious in its effects. I have found it hard to determine the intrinsic gravity and seriousness of the condition. The error lies, unquestionably, in underestimation. One is apt not to intervene until the intestine becomes the seat of infarcts. The conclusion is unescapable that immediate operation is indicated. Caution must be exercised in calling a case subacute in character.

When the obstruction takes place during convalescence, the question arises whether one should enter the abdomen through the original incision. If this incision is still draining, or though primarily closed, has reopened from infection, the new incision should be placed elsewhere; otherwise infection may be transmitted to the central abdomen and peritonitis rapidly engendered. Ample room is needed to deal satisfactorily with the lesion. Naturally, if a short-circuiting operation is chosen, generous exposure is requisite. If a concomitant pelvic lesion is suspicioned, the lower extremity of the right rectus incision is curved downward and inward, forming a modified hockey stick incision. This extension permits a larger exposure of the pelvic organs and grants sufficient freedom for the proper operative treatment of the tubes. If the distention is severe, caution is exercised in divid-

ing the peritoneum, for the intestine may be firmly pressed against the anterior abdominal wall. One should endeavor to avoid evisceration, as the prolapse of the distended coils increases the likelihood of shock, entails excessive manipulation, and favors peritoneal infection. Evisceration is distinctly objectionable. It is a positive excitant to shock; in point of fact, nothing produces shock so quickly in dogs, as evidenced by physiologists in experimental animal work. In order to lessen the likelihood of the occurrence of shock, it is the custom to cover the protruded intestinal coils with towels of hot saline solution. This is done to lessen the loss of heat. Though this step is necessary under these circumstances, it introduces the principle of wet operating which is so productive of peritonitis. Moreover, there is not only the danger of losing or enclosing towels and sponges, but one finds that constant pressure from an assistant's hands is needed to prevent the intestine from sliding from the abdominal wall. A short primary incision decreases the possibility of evisceration; but, a generous use of laparotomy pads, rapidly introduced, is the best method to prevent the protrusion of the intestines.

The large intestine is palpated in a systematic manner. Beginning with the cæcum, the examining hand passes in sequence to the flexures and ends at the rectum. This is a crucial step. The large intestine is not easily mobilized, and can, only with difficulty, be brought to the margin of the incision for inspection. It is essential, however, to determine definitely the state of the sigmoid and the rectum. The technique thus outlined is followed when the small intestine is distended, for this inevitably proves that the obstruction is at a lower level. When a loop of small intestine is seen, collapsed and ribbon-like in appearance, the operator should grasp and follow it to the site of obstruction, which must, inevitably, be at a higher level. It is difficult, at times, to know whether one is passing up or down the small intestine. This can occasionally be determined by the direction and inclination of the mesentery, for the mesentery of the small intestine, it will be recalled, passes, in general, from above, downward, and to the right, across the vertebral column. If the surface of the mesentery can be seen, one can easily determine whether a twist or a torsion is present. A reddening of the peritoneum is most intense at the site of obstruction.

In the simpler cases the division of a band or the releasing of a kink may be curative. On the other hand, these minor procedures may not be sufficient to relieve the obstruction, or though the obstruction is relieved, distention persists. Following the surgical relief of an obstruction of the small intestine, it is not an uncommon experience for the patient to succumb with symptoms indicative of severe toxæmia. Despite the relief of obstruction, the complete technical success, and the evident immediate improvement, a complete change in the patient's condition may take place within a few hours. The exact mechanism underlying this form of postoperative death is not accurately understood. The usual explanation is that, following the relief of the obstruction, the highly toxic material dammed behind the obstruction passes quickly into the unobstructed segment, where its rapid absorption causes death. It is still a mooted question whether the cause of death is chemical or bacterial.

It is probable that active processes in the wall of the intestine may play a part in the mechanism. In operations for acute obstruction, involving the small intestine, it is a matter of general observation to note that the segment oral to the point of obstruction is usually markedly distended and the color greatly changed. The color, as a rule, is a cherry red, or perhaps, dark brown or black, according to the degree and state of the arterial or venous obstruction. These appearances are in marked contrast to the size and color of the aboral intestine. This segment is generally collapsed, resembling a flat tape; it is pale pink in color and void of contents. Keeping these two diverse conditions in mind, it is evident that when the obstruction is relieved, the contents of the oral segment pass rapidly into the collapsed bowel, the absorbing capacity of which must be augmented. While the relief of the obstruction is an advantage from the mechanical view-point, it

is patent that a possible injury may result, in that, the toxic material is permitted to flow to a fresh intestinal surface, where absorption is rapid and fatal. Thorough post-mortem studies are needed to explain these cases. At operation, one is struck with the numerous areas of dark discoloration on the wall of the distended intestine. It is possible that these represent infarcts, of greater or less extent, caused by an obstruction of the mesenteric arteries and veins. From the macroscopic examination of the intestine at operation, it is difficult owing to lack of time to decide whether this infarct is arterial or venous. No doubt exists that these lesions must be considered as possible factors in the sudden death of the patient.

The occurrence of sudden death is indeed so striking that in order to obviate this result, surgeons have advised the incision and drainage of the distended loop before the relief of constriction. From a practical view-point, the procedure is not always easy to accomplish. There constantly exists the danger of accidental contamination of the peritoneum, during the process of emptying a coil. A short-circuiting operation, might, conceivably, eliminate the danger of rapid absorption, provided the anastomosis was made to some part of the colon, for this part of the intestine appears to possess inherent means of defense against bacterial and toxic absorption, a function, no doubt, acquired through heredity, or explained by the fact that the toxic material is more quickly evacuated. It is in this connection that the operation of ileocolostomy is available.

The terminal ileum, if the site of adhesions, is apt to present a characteristic appearance. The last few feet of the intestine are folded in a more or less continuous pleated manner, the individual arms of the pleat being comparatively short. It is manifest that the matted condition should remain untouched and no attempt be made to disentangle the tortuous loops. An elaborate dissection would inevitably lacerate the intestine or injure a mesenteric vessel. Any operative manipulation would expose the patient to the dangers of peritonitis and hæmorrhage. If these accidents were of moment, a resection would be indicated. Moreover, a dissection of the adhesion would prove valueless, for, within a few hours, the process of agglutination would recur, resulting perhaps, in a form of adhesion more complicated than the original state. No attempt, therefore, should be made to dissect extensive adhesions of the terminal ileum. Another procedure must be employed. In the operation of ileotranscolostomy, there exists an ideal technical procedure for obstruction of the lower ileum, due to a matted, twisted or adherent ileum. The prevention of toxæmic absorption and the necessity of avoiding an extensive dissection of the terminal ileum present the two main indications for a short-circuiting operation.

Ileotranscolostomy signifies the union of the terminal ileum to the beginning of the transverse colon. The indication for this operation is furnished by an insuperable obstruction located in the terminal ileum, the cæcum, or the ascending colon. It obviates the performance of an enterostomy or a cæcal fistula. An enterostomy, though highly recommended by eminent surgeons, makes no general appeal. It is, admittedly, a makeshift. I refer, specifically, to the disadvantages accruing from the irritation of the skin and the loss of nutritive fluids in a patient already weakened and debilitated. The main objection consists in the uncertain technique. To secure the intestine to the margin of the peritoneum, is merely to invite the development of peritonitis. To draw the loop outside the abdomen, means a secondary operation, possibly a resection. To find and verify the lower ileum requires considerable handling. In my experience, opening of the bowel has caused collapse of but a few feet of intestine. Personally, I have discarded this practice, for its so-called advantages appear purely chimerical. The operation can be easily performed through a right rectus incision. As a rule, the ileum, at a point about six inches from the ileocæcal valve, can be apposed without undue tension or traction, to the first one-third of the transverse colon. It will be recalled, in this connection, that the transverse colon is exceedingly mobile, and that the weight of the attached omentum acts as a downward pulling force. The ileum, at two points, is

united with linen traction sutures to a longitudinal band of the transverse colon. It is often difficult during the performance of an operation for intestinal obstruction, from distention of the intestine, accurately to determine the location of the small intestine, selected to be opened. Naturally, if the band selected is the jejunum, or upper part of the ileum, there will exist grave danger to the patient from malnutrition and exhaustion, caused by the loss to the body of nutritive fluids.

In order to prevent the escape of the intestinal contents, occlusion is obtained by the use of gauze tapes. Though intestinal holding clamps with blades ensheathed in rubber tubing are widely used for this purpose, increasing experience proves that they are cumbersome and inconvenient, particularly during the necessary turning and manipulation of the intestine. Moreover, they have a tendency to slip and are difficult to apply with the proper degree of pressure. On the other hand, gauze tapes are usually available, but, if not, can be quickly improvised. They are easily applied. With a blunt nose hæmostat, the mesentery is pierced close to the intestinal border, the jaws of the clamp are partially opened, and a thin, flat tape passed through the hole. The tape is tied with a simple bow-knot which permits its ready release.

The anastomosis is of the antiperistaltic type. In order to make an isoperistaltic anastomosis, it is necessary to turn the ileum in a direction the reverse of its normal course. This step, consequently, would occasion a twist in the mesentery, and possibly cause an interference of the circulation of the mesenteric vessels. Moreover, there is a probability that so extreme a torsion would favor the occurrence of volvulus. The technique of the suture is the same as that of a lateral anastomosis. The method suggested by William J. Mayo, for posterior gastrojejunostomy, is, perhaps the best. The omentum, fortunately favorably placed, may be utilized in the protection of the suture line. By disposing it in front of the suture line, at the completion of the anastomosis, considerable security is granted.

In a young man with acute intestinal obstruction, caused by an occluding carcinoma of the cæcum, I performed an anastomosis, with immediate relief, between the ileum and the transverse colon. Several weeks following, intermittent attacks of abdominal pain hastened the secondary operation for the removal of the growth, which operation I had hoped, in order to improve nutrition, to postpone for a longer period. At this secondary operation, a large mass of the small intestine was found herniated to the right, beneath the loop passing to the colon for the anastomosis. The reduction was simple and did not interfere with the subsequent resection of the cæcum and ascending colon. The accident demonstrated, however, the need to obliterate any potential opening in the peritoneum, in the performance of a lateral anastomosis (short-circuiting) operation. It will be recalled that Arbuthnot Lane experienced a similar difficulty in his operation of ileosigmoidostomy, which to overcome, the small intestine is entirely eviscerated, in order to suture its mesentery to that of the descending colon. A remedy consists in approximating and suturing the ascending colon, or hepatic flexure, to the anastomosing loop. In case of a subsequent resection of the cæcum and the ascending colon, the outer end of the transverse mesocolon may be directly united to the divided mesentery of the ileum.

Appended are the author's personal cases. Case 5 is inserted because of its close relationship from a technical view-point.

CASE 1. Acute intestinal obstruction caused by a band strangulating the lower ileum. Appendectomy two years previous. J. P., age 16, admitted with the diagnosis of acute intestinal obstruction, December 24, 1913; discharged January 10, 1914. Two years ago the appendix was removed at another hospital. The present illness began three days ago with severe abdominal pain, situated mainly in the right lower quadrant. There was vomiting and obstipation. The abdomen was slightly distended. There was a soft mass in the right iliac fossa. The scar of a previous right rectus incision could be seen. Immediate operation. A right rectus incision disclosed an intestinal obstruction of the lower ileum. The distal end of the ileum was purple in color, thickened and distended. The mesentery was greatly swollen and presented several lacerations. A band, 2½ inches long and ¾ inches wide passed between the cæcum and the parietal peri-

toneum. The ileum was strangulated by this band. The band was ligated and divided. Hot towels applied to the ileum quickly restored the circulation. The abdominal wall was closed in layers. Primary union. Recovery.

CASE 2. Acute intestinal obstruction of the ileum following appendectomy. Ileocolostomy. Recovery. M. H., female, age 19, admitted, August 18, 1914. Discharged, September 26, 1914. Eleven months previous to admission an appendectomy was performed for acute appendicitis. The ligation method, with cauterization of the stump with phenol and alcohol, was used. The patient remained in the hospital 16 days. Primary union. Discharged cured. Since this operation she has been perfectly well, until about two weeks before admission, when she experienced severe and constant pain in the abdomen. One week before admission constipation was marked, cathartics and enemas failing to give relief. She vomited several times each day, and on the day of admission, fæcal vomiting was noted. On examination, symptoms of grave toxæmia were detected. The pulse was exceedingly rapid and the abdomen distended. No visible peristalsis; no mass felt. Operation on August 18, 1914. Right rectus incision. The small intestine was found greatly distended. Many adhesions existed around the terminal ileum. An attempt was made to separate these adhesions, but was abandoned because of the technical difficulty. A free loop of the ileum, immediately above the area of the adhesions was anastomosed to the transverse colon. The abdomen was closed with through-and-through sutures. The postoperative course was smooth until on August 24, sixteen days following operation, when nausea and constant vomiting began. The following day the abdomen became distended and the bowels could not be moved. On the 26th, the vomiting was constant, the abdomen distended, and the pain severe. The patient improved slightly the following two days. An X-ray showed an obstruction of the small intestine in the afferent loop. A secondary operation was performed August 29, 1914. The anastomosis was found in an excellent condition. A portion of the transverse colon was adherent to the small intestine, close to the anastomosis. The adhesion was divided and the obstruction relieved. Wound resutured. Primary union. Discharged cured.

CASE 3. Acute appendicitis with spreading peritonitis. Appendectomy. Acute intestinal obstruction. Enterostomy. Death. S. T., age 26, admitted, November 20, 1914, died, November 29, 1914. The present illness began with severe pain in the abdomen two days previous to admission. She has had two former attacks, one six months ago, and one two months ago. On examination, there were found the typical symptoms of acute appendicitis. A mass was felt in the right lower quadrant. An intermuscular incision. The appendix was about three inches long, gangrenous and perforated at the tip. There was considerable free pus with a marked fæcal odor. The patient did not do so well. The pulse increased in rapidity, became small, and the patient vomited constantly. On November 28, the distention was great, the obstipation complete, and the vomiting profuse. Immediate operation. Median incision. A kink was found in the ileum about six inches from the cæcum. The kink was relieved by dividing numerous adhesions. As complete stasis of the upper bowel existed, an enterostomy was done. The patient died twenty-four hours following operation.

CASE 4. Acute appendicitis with abscess. Drainage operation. Acute intestinal obstruction, from two constricting bands. Ileotranscolostomy. Recovery. J. B., admitted, November 20, 1916, discharged, February 2, 1917. Has had several previous attacks. The patient was well up to nine days prior to admission. The pain in the abdomen has become generalized, radiating to the right iliac fossa. The patient has vomited three times. No obstipation. On examination, there was felt in the right iliac fossa, a dense globular mass. Dullness could be elicited over the same area. There was considerable pain on palpation. Pelvic examination was negative. Right rectus incision. An appendicular cavity containing foul pus was entered. The appendix was not sought as it formed part of the wall of the abscess. The cavity was packed with plain gauze and the abdominal incision partially closed in layers. The patient did well for four days. On the fifth, the abdomen showed marked distention and hiccoughs appeared. The symptoms continued several days and were finally relieved by colonic irrigation. The wound edge, however, was widely opened. Twenty days following operation, distention and pain and visible peristalsis were noted. It was evident that symptoms of obstruction were present. Operation on December 15, 1916. Median incision. Small intestine greatly distended, especially the jejunum and upper portion of ileum. A band, ¼ inch thick, was ligated and divided. A second band was found and cut. The lower portion of the ileum was collapsed. In the right iliac fossa there were dense adhesions between the ileum and the cæcum. A distended loop of small intestine was isolated and anastomosed to the transverse colon. The abdominal wall was closed. An intravenous injection was given on the table. The patient made a slow but a constant recovery. Discharged, cured, February 2, 1917.

CASE 5. Volvulus of cæcum with Jackson's membrane. Ileotranscolostomy. Later resection of the cæcum, ascending colon and ileum. Age 31, admitted to hospital August 7, 1913. Family and personal history negative. The present illness began with severe cutting pain in the right side of the abdomen, and vomiting. On admission to the hospital, a mass could be felt in the right lower quadrant; rigidity of the recti and dullness on percussion, in the right iliac fossa. Temperature 99.4.° Pulse 80. Ether narcosis. Exploratory laparotomy. A large cystic mass was felt occupying the right iliac region

and the upper part of the pelvis. At first, it appeared like an ovarian cyst with a twisted pedicle. On closer examination, the cæcum, the ascending colon, and the terminal ileum were found intimately bound together and rotated in a longitudinal direction; in other words, a partial volvulus. On closer examination a membrane was found which passed down over the cæcum, covering and enclosing the appendix. This membrane also passed down over the terminal ileum. An attempt was made to free the ileum by dissecting the adhesions but it was given up for fear of wounding the small intestine. A short-circuiting operation was done. The ileum was divided; the oral end closed with four layers of sutures and a lateral anastomosis made with the beginning of the transverse colon. The aboral ileum was closed and lightly sutured to the lower end of the incision. No tension or dragging was necessary in order to bring the ileum to the colon. Uneventful recovery took place. On August 21, the ascending colon, the cæcum, and terminal ileum were removed in one mass. Complete recovery.

CASE 6. This patient had been ill thirty-six hours before admission, with the classical symptoms of acute appendicitis. Operation August 14, 1918. A short right rectus incision revealed a moderately inflamed appendix. It was removed by the ligation method and cauterization of the stump with phenol and alcohol. The post-operative course was smooth until the fourth day, when severe abdominal pain occurred. The pain rapidly increased in intensity and vomiting took place. Enemata were without result. In view of the presence of severe abdominal pain, vomiting and complete obstipation, an immediate operation was performed. A loop of ileum was found adherent to the cæcum. The adhesion was divided and the intestine liberated. Uneventful recovery.

CASE 7. A young married woman had had an appendectomy done the year before. A right rectus incision had been used. The method of treatment of the stump was not ascertained. The patient complained of severe abdominal pain. There seemed to be an element of hysteria present but the attending neurologist, Dr. Joseph Byrne, reported that he believed the pain to be of organic origin. Operation, February 2, 1918, revealed a loop of the ileum adherent to the parietal peritoneum. Uneventful recovery.

CASE 8. Mr. F., age 35, admitted to St. Francis Hospital, December 27, 1918. He was operated on seven years ago in Bellevue Hospital for acute, suppurative appendicitis. Drainage was evidently employed, for the appendix scar is broad. For the past six months he has suffered from gastric symptoms. Complains of pain after eating. No history of the vomiting of blood. Present illness: Today, he was taken suddenly ill with severe and agonizing abdominal pain and vomiting. The pain is referred to the central part of the abdomen. The patient appears pale and weak. The condition looks as if it were perforation of a duodenal ulcer, or a secondary obstruction due to the previous operation. The abdomen is rigid. Immediate operation. Right rectus incision. A small amount of clear fluid escaped from the peritoneal cavity. The transverse colon and the cæcum were contracted and empty A loop of the small intestine brought up was empty. A second loop was greatly distended and contained fluid. The surface of the intestine presented numerous areas of dark discoloration. Diagnosis: Acute intestinal obstruction. In the region of the previous operation, a thin band was found, which passed from the parietal peritoneum, in the region of the scar, upward and inward, to the convex border of an intestinal loop. This band compressed and completely obstructed a second loop of small intestine. The band was divided and excised. The abdomen was closed without drainage. Primary union. Discharged cured.

CASE 9. A young woman age 30, single, admitted to Fordham Hospital, March 18, 1919. An appendectomy had been performed, May, 1918. No drainage employed at that time. Since the operation, she has suffered from more or less abdominal pain and constipation. March 17, she was taken suddenly ill with severe abdominal pain, located in the right lower quadrant. She had been constipated for two days previous and had vomited several times during the day. On admission, the patient presented a right rectus incision, about three inches long. The abdomen was distended and there was more or less rigidity, particularly, in the lower half of the right rectus. A point of extreme tenderness was situated immediately over the scar. Temperature normal. Diagnosis: Acute intestinal obstruction. Immediate operation. Ether narcosis. Right rectus incision, four inches long, one inch internal to the old scar. Upon opening the abdomen, clear fluid escaped in a large amount. A loop of small intestine projected itself at once into the wound. It was distended and filled with gas and fluid. At the same time, a second loop of small intestine, completely collapsed, appeared in the lower angle of the incision. It was evident by the marked difference in the appearance of the two loops of intestine, that a complete obstruction existed. Upon pulling gently on the collapsed intestine the obstruction was reached. This was caused by a loop of the small intestine being firmly adherent to the parietal peritoneum, immediately behind the old incision. The point of adhesion was about 1¼ inches long and attached to the convex border of the intestine, in a direction corresponding to the long axis of the intestine. Separation of this adhesion tore slightly the peritoneal coat of the bowel. This laceration was repaired with two layers of interrupted linen. Further examination revealed a thickened band passing from the cæcum to the parietal peritoneum. This band was at least three inches long and appeared to be an extension of an appendix epiploica. Ligation and excision of the band. Closure of the abdomen without drainage. Complete recovery and discharge.

THE STATUS OF THE VESICAL SPHINCTER AFTER PROSTATECTOMY

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THE functioning result of prostatectomy may candidly be stated as good in by far the majority of cases. The occasional instance in which this is not so may be due to one or more of several reasons. The two chief factors that should be considered in explanation of unsatisfactory function after prostatectomy are: (1) the incomplete removal of the obstruction, and (2) the too extensive trauma to adjacent parts incident to removal of the hypertrophied lobes. In this latter group the resulting condition of the sphincteric fibers about the vesical orifice and posterior urethra may be considered.

The part played by the internal or vesical sphincter and the external or urethral sphincter has long been a subject of much diversity of opinion. It is only during recent years that sufficient evidence has been brought forth to establish definitely which normally constitutes the closing muscle of the bladder. Finger (1) has consistently maintained that the internal sphincter is far too weak a muscle to withstand the pressure of urine and prevent its escape from a distended bladder. Likewise Ultzman (2) and Guyon (3) have shared the same opinion, i.e., that the vesical or internal sphincter gives away under marked bladder distention and that the posterior urethra virtually becomes a part of the bladder cavity; at this juncture the external sphincter or compressor urethræ muscle forms the closing point of the bladder. Rehfish (4), on the other hand, was one of the first to point out that the action of the external sphincter is really very slight. In his experiments he placed a catheter in the prostatic urethra of an individual with a distended bladder (beyond the external sphincter) and obtained no urine. When the patient voided, urine came both through and around the catheter and on stopping all urine ceased to flow. From this observation he concluded that the internal or vesical sphincter was the normal closing muscle of the bladder. The method of studying the bladder outline by means of collargol cystograms first introduced by Voelcker and Lichtenberg (5) has done much to settle our views as to which muscle normally forms the true urinary sphincter. The above observers found that in the normal bladder the shadow is always sharply delineated as an uninterrupted segment of a circle and no collargol escapes beyond the internal vesical sphincter into the posterior urethra even with a greatly distended bladder. The subsequent work of Leedham-Green (6), Barringer and MacKee (7), Uhle (8), Hyman (9), and others have amply confirmed this view. At the present time it is generally accepted that the internal sphincter marks the normal closing point of the bladder.

In prostatectomy whether by the suprapubic or perineal route there is always the possibility of a certain amount of trauma to the sphincteric fibers about the bladder orifice and posterior urethra. This is of varying extent dependent upon the size of the prostatic lobes removed, upon the care exercised in their enucleation and also upon the method of prostatectomy, i.e., suprapubic or perineal. Some observers, notably Wallace (10), go so far as to state that in marked hypertrophy the adenomatous mass sometimes works its way through and distends the sphincter to such a degree as to render it probably useless. If that is true the vesical sphincter is atonic in certain extreme cases even before operation is undertaken. Regarding the fate of the vesical sphincter after operation, Squier (11) is of the opinion that the internal sphincter remains intact and soon contracts to its normal caliber. Speaking of the loss of urinary control after prostatectomy Hagner and Fuller (12) state that the subject is a debatable question but is unquestionably due to the destruction of the muscle at the neck of the bladder (internal sphincter), in the prostatic urethra or in the membranous urethra. Hyman has recently given us a very conclusive study of the resulting changes at the bladder outlet following suprapubic prostatectomy by means of collargol cystograms. In a series of 38

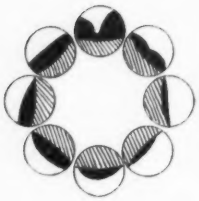

Fig. 1.

Fig. 1. Case 1. Both lateral lobes are hypertrophied, the right more that the left. There is also some enlargement of the middle lobe.

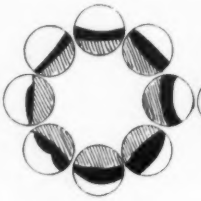

Fig. 3.

Fig. 3. Case 2. The middle lobe is enlarged. The left lateral lobe shows only moderate hypertrophy and the right very little.

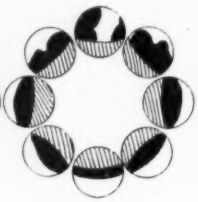

Fig. 5.

Fig. 5. Case 3. Both lateral lobes are markedly enlarged with margins somewhat irregular. The middle portion is also enlarged and continuous with the lateral lobes.

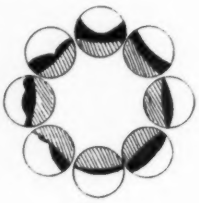

Fig. 7.

Fig. 7. Case 4. Slight median enlargement (form of a bar) with also a definite hypertrophy of both lateral lobes.

Fig. 2.

Fig. 2. Case 1, roentgenogram No. 608. Cystogram taken three weeks after operation shows the bladder outline round with margins regular. The vesical orifice is regular and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 400 cubic centimeters.

Fig. 4.

Fig. 4. Case 2, roentgenogram No. 536. Cystogram taken three and a half weeks after operation. The bladder shadow is rounded, and somewhat irregular. The bladder orifice is normal with no dilatation of the internal sphincter. Residual urine 0; bladder capacity 475 cubic centimeters.

Fig. 6.

Fig. 6. Case 3, roentgenogram No. 585. Cystogram taken three and one half weeks after operation. The bladder outline is rather wider than normal. The prostatic orifice is regular, no dilatation of internal sphincter. Residual urine 0; bladder capacity 200 cubic centimeters.

Fig. 8.

Fig. 8. Case 4, roentgenogram No. 530. Cystogram taken four weeks after operation. The bladder outline is normal. The orifice is normal and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 375 cubic centimeters.

cases he found that 28 showed two distinct cavites after operation, the bladder cavity and continuous with it the one from which the prostatic adenoma was removed. In these cases the external sphincter marked the closing point of the bladder. Of the remaining 10 cases, a few showed a very slight funnel formation and the rest no change from the normal. He states that the internal sphincter has been destroyed by operation or its function so impaired that it could not have had any effect in retaining the fluid in the bladder.

From Hyman's study it is readily seen that though the internal or vesical sphincter is destroyed in the majority of cases of suprapubic prostatectomy, still no incontinence follows. Yet under normal conditions this same vesical sphincter is the muscle which holds the urine in the bladder. Occasionally we meet with an individual that has continued incontinence following the above type of operation. Our only explanation for this is that in removing the hypertrophied lobes an unwarranted amount of trauma has been done to the posterior urethra, i.e., its involuntary musculature, in addition to permanently injuring the internal sphincter. These involuntary muscles of the posterior urethra composed of two layers, an inner longitudinal and an outer circular, innervated by branches from the prostatic and cavernous plexus, inferior mesenteric ganglion and ganglia of the sympathetic, the same as

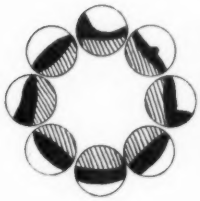

Fig. 9.

Fig. 9. Case 5. Both lateral lobes are enlarged. The middle portion is definitely lobular as shown by the cleft between it and the left lateral lobe.

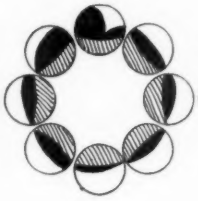

Fig. 11.

Fig. 11. Case 6. Marked right lateral lobe enlargement. The left lateral is moderately enlarged with only slight increase in size of the middle lobe.

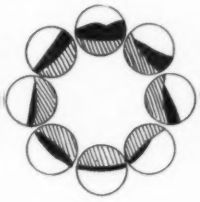

Fig. 13.

Fig. 13. Case 7. Moderate enlargement anteriorly with very slight involvement of the lateral lobes. The middle portion is definitely hypertrophied.

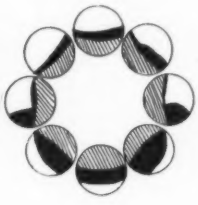

Fig. 15.

Fig. 15. Case 8. Definite middle lobe hypertrophy with practically no involvement of the lateral areas.

Fig. 10.

Fig. 10. Case 5, roentgenogram No. 605. Cystogram taken five weeks after operation shows the bladder shadow round with margins slightly irregular. In the region of the prostatic orifice the shadow is normal and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 375 cubic centimeters.

Fig. 12.

Fig. 12. Case 6, roentgenogram No. 588. Cystogram taken four months after operation. The bladder outline is somewhat larger than normal and pyramidal in shape. The vesical orifice is regular and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 300 cubic centimeters.

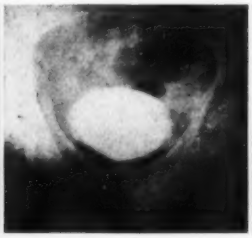

Fig. 14.

Fig. 14. Case 7, roentgenogram No. 498. Cystogram taken five months after operation. The bladder shadow is oval in outline, with lateral margins somewhat irregular. The vesical orifice is normal and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 175 cubic centimeters.

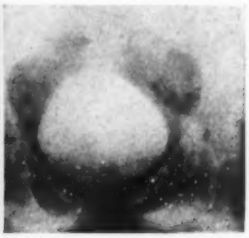

Fig. 16.

Fig. 16. Case 8, roentgenogram No. 515. Cystogram taken six months after operation. The bladder outline is somewhat oval, with margin regular. The vesical orifice is normal and shows no dilatation of the internal sphincter. Residual urine 40 cubic centimeters; bladder capacity 400 cubic centimeters.

the internal sphincter itself, unquestionably exert a very definite supporting action to the function of the vesical sphincter (13). Not every case of suprapubic prostatectomy has a permanently dilated vesical sphincter as was shown by Hyman. We know this must be so also from an occasional complete occlusion of the internal vesical orifice following suprapubic enucleation as has been reported by Gordon (14), Denslow (15) and others, and as has been once observed by the writer. In this complication the mucous membrane in its growth bridges over the internal orifice and completely occludes it which occurrence is hardly possible with a permanently dilated vesical sphincter. The action of the external sphincter, a purely voluntary muscle and directly under the control of the will, can hardly be accredited with the power of remaining tonically contracted for a period long enough to give normal urinary continence. The method of removing the prostate through the perineum, by reason of the approach through incisions in the posterior lobe, and oftentimes its successful enucleation without rupturing the bladder mucosa at all seemed to offer possibilities for observations on the vesical outlet under conditions quite different than after suprapubic prostatectomy.

For the purpose of this study 25 cases were obtained from the clinic of the James Buchanan Brady Urological Institute. The recent cases

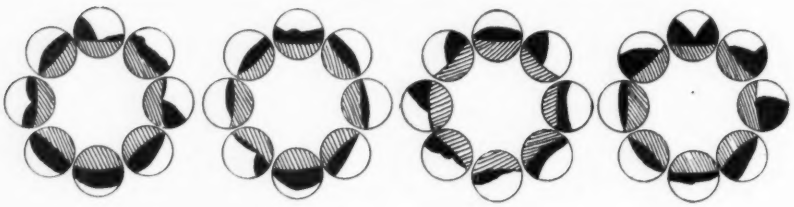

Fig. 17. Fig. 19. Fig. 21. Fig. 23.

Fig. 17. Case 9. Mostly a middle lobe hypertrophy with moderate enlargement of the right lateral. Practically no left lateral lobe involvement.

Fig. 19. Case 10. Marked middle lobe hypertrophy with relatively little enlargement of either lateral lobe.

Fig. 21. Case 11. Somewhat distorted right lateral lobe hypertrophy. The middle portion is slightly elevated and the left lateral lobe only moderately involved.

Fig. 23. Case 12. Enlargement of both lateral lobes with also a median lobe hypertrophy.

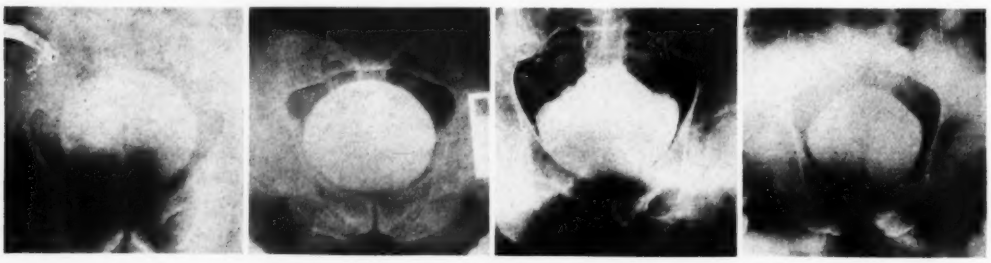

Fig. 18. Fig. 20. Fig. 22. Fig. 24.

Fig. 18. Case 9, roentgenogram No. 570. Cystogram taken eight months after operation. The bladder shadow is round in outline with margins regular. The vesical orifice is normal and shows no dilatation of the internal sphincter.

Fig. 20. Case 10, roentgenogram No. 540. Cystogram taken seven months after operation. The bladder outline is normal. The vesical orifice is regular and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 375 cubic centimeters.

Fig. 22. Case 11, roentgenogram No. 607. Cystogram taken ten months after operation, shows a bladder somewhat oval with margins somewhat irregular. The region of the vesical orifice is smooth and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 325 cubic centimeters.

Fig. 24. Case 12, roentgenogram No. 523. Cystogram taken eleven months after operation. The bladder outline is normal. The vesical orifice is regular and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 300 cubic centimeters.

were obtained during the convalescence of the patients in the hospital. The older cases were taken from those living near by and the first 25 cases thus obtained will be reported in detail. The description of these includes the salient points in the rectal examination made by one of the staff on the patient's admission to the hospital, recording the amount of prostatic hypertrophy noted per rectum. This is supplemented by a cystoscopic examination and study of the prostate intravesically. In these examinations a cystoscope giving an inverted image was used, usually the Nitze photographic model. Only the descriptions of the prostate itself are taken from the records and each of these is supplemented by a drawing on a cystoscopic chart as suggested by Young (16) made at the time of examination graphically to represent the intravesical prostatic hypertrophy. The normal prostatic margin is here outlined in diagonal lines, while the superimposed pathological hypertrophy is recorded in black. The operation performed in every case has been Young's (17) conservative perineal prostatectomy done by Young or one of his staff. This operation in brief is a perineal dissection, through an inverted V skin incision, the patient being placed in the exaggerated lithotomy position. After cutting through the central tendon of the perineum, the membranous urethra is exposed, and with the bulb and external sphincter muscle drawn forward, is incised on a sound previously placed in the urethra. A prostatic

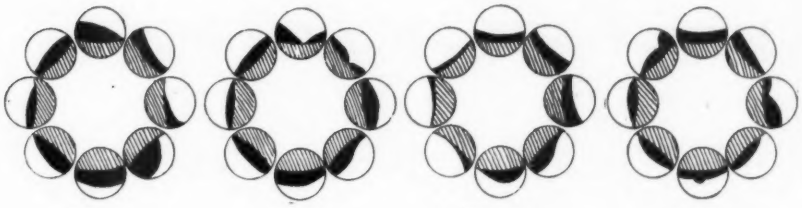

Fig. 25. Fig. 27. Fig. 29. Fig. 31.

Fig. 25. Case 13. Globular median lobe continuous with a definite right lateral lobe hypertrophy. The left lobe is not enlarged.

Fig. 23. Case 14. "Collar" type of hypertrophy including both lateral lobes joined by an enlarged middle lobe.

Fig. 29. Case 15. Mostly a middle lobe enlargement with no enlargement of the right lateral lobe and only slight involvement of the left lateral lobe.

Fig. 31. Case 16. Globular middle lobe with slight hypertrophy of the right lateral lobe. The left lateral lobe is not appreciably enlarged.

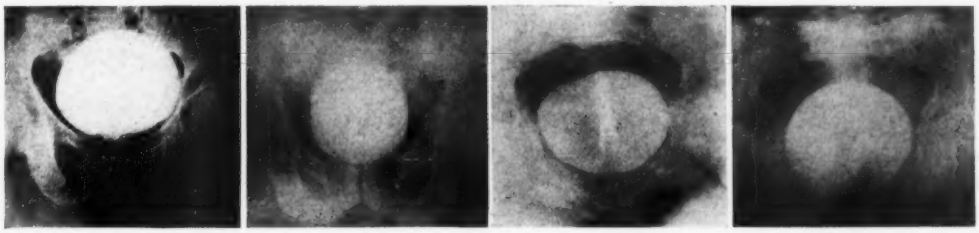

Fig. 26. Fig. 28. Fig. 30. Fig. 32.

Fig. 26. Case 13, roentgenogram No. 517. Cystogram taken thirteen months after operation. The bladder is round in outline with margins regular. The vesical orifice is normal, and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 300 cubic centimeters.

Fig. 28. Case 14, roentgenogram No. 511. Cystogram taken fourteen months after operation. The bladder is normal in outline. The vesical orifice is regular and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 225 cubic centimeters.

Fig. 30. Case 15, roentgenogram No. 563. Cystogram taken fourteen months after operation, shows bladder outline normal with margins irregular. Region of vesical orifice smooth, no dilatation of internal sphincter. Residual urine 0; bladder capacity 400 cubic centimeters.

Fig. 32. Case 16, roentgenogram No. 544. Cystogram taken fifteen months after operation shows bladder outlines normal with prostatic margin smooth and there is no dilatation of the internal sphincter. Residual urine 0; bladder capacity 400 cubic centimeters.

tractor is then placed through the urethrotomy opening into the bladder and with this the prostate drawn up into the wound. The rectum is then pushed back and the prostate exposed covered only with the anterior layer of the fascia of Denonvillier. Two perpendicular incisions are then made through the capsule and posterior lobe, on either side of the mid line, avoiding in this way the ejaculatory ducts. Through these incisions the hypertrophied lateral and middle lobes are enucleated. A large catheter is then placed through the urethrotomy wound into the bladder and the lateral cavities of the prostate packed with gauze. The levator ani are then brought together with a single stitch and the skin approximated.

In every case is noted the beginning of interval urination, indicating from a functional standpoint the return of control in the internal sphincter. The study of the vesical orifice was made in these cases by means of cystograms taken some time subsequent to operation, i.e., three weeks to thirteen years. These were made after filling the bladder with 10 per cent thorium solution through a catheter as recommended by Burns (18) and studying the bladder outlines and particularly the region of the prostatic orifice for evidences of dilatation, as shown by the escape of the thorium solution into the posterior urethra.

CASE 1. G. M. G.— B. U. I. No. 5237, 63-W. Complaint: difficulty in urination.

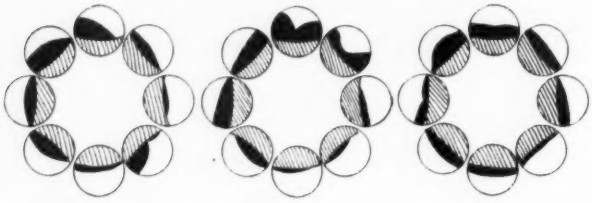

Fig. 33. Fig. 35. Fig. 37.

Fig. 33. Case 17. Definite right lateral lobe hypertrophy with also a globular middle lobe. No appreciable enlargement of the left lateral lobe.

Fig. 35. Case 18. Hypertrophy of both lateral lobes which masses are joined together by a small "median bar" formation.

Fig. 37. Case 19. Moderate hypertrophy of both lateral lobes which masses are joined by a small middle lobe enlargement.

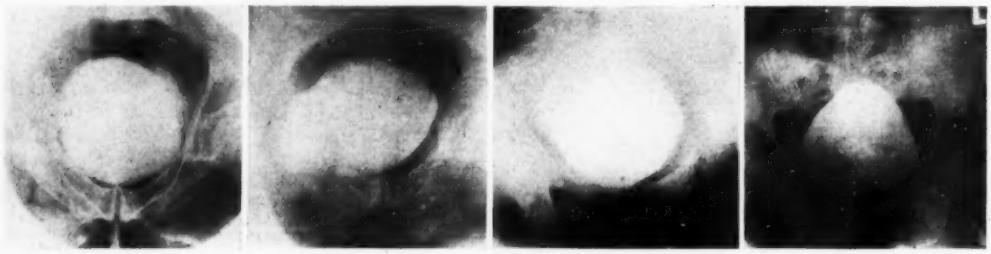

Fig. 34. Fig. 36. Fig. 38. Fig. 40.

Fig. 34. Case 17, roentgenogram No. 573. Cystogram taken sixteen months after operation shows bladder outline normal with margins regular. The region of the vesical orifice is smooth and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 225 cubic centimeters.

Fig. 36. Case 18, roentgenogram No. 679. Cystogram taken twenty months after operation. The bladder outline is oval and regular. The region of the vesical orifice is sharply delineated and shows no evidence of dilatation of the internal sphincter. Residual urine 0; bladder capacity 350 cubic centimeters. In a cystogram of this patient taken fourteen months after operation the internal sphincter was found to be dilated. See roentgenogram, Fig. 38, No. 508.

Fig. 38. Case 18, roentgenogram No. 508. Cystogram taken fourteen months after operation. The bladder outline is oval and regular. The internal sphincter is dilated and posterior urethra is funnel shaped as shown by the escape of thorium into the prostatic urethra. Residual urine 0; bladder capacity 325 cubic centimeters. A later cystogram of this patient twenty months after operation shows the internal sphincter tightly closed, demonstrating that the internal orifice may return to normal even after a considerable interval of relaxation.

Fig. 40. Case 19, roentgenogram No. 525. Cystogram taken 21 months after operation, shows bladder outline oval with margins regular. Region of vesical orifice smooth, no dilatation of the internal sphincter. Residual urine 0; bladder capacity 300 cubic centimeters.

Rectal examination. The prostate is considerably enlarged, being a great deal broader than normal and more prominent toward the rectum. Its long diameter is also apparently increased. The median furrow is very shallow, almost obliterated. The right lobe is smooth, everywhere elastic, there being no suspicious areas felt, although it is impossible to reach the upper limit. The left lobe is somewhat irregular, but its consistency is everywhere elastic.

Cystoscopy. Residual urine. Retention. Bladder capacity 300 cubic centimeters. Study of the prostatic orifice shows a shallow cleft a little to the left of the midline anteriorly. The right lateral lobe is quite irregular and shows some intravesical enlargement. It is continuous with a fairly enlarged median which obscures practically all of the trigone. The median joins and is continuous with the left lateral lobe which is slightly enlarged. The trigone is normal in appearance except for some elevation and hypertrophy, there being a shallow pouch behind it.

Operation. Two lateral incisions were made into the posterior lobe. The right lobe was delivered in one piece. The left lateral and median were removed in one piece, the median being adherent to the left lateral. On exposing the surface of the prostate a small lobule was noted, which had also been noticed before operation. This was apparently a cyst measuring 4 millimeters in diameter. After removing the prostate the finger was introduced into the wound and the internal orifice felt to be intact. The sphincter was also felt. The patient voided at intervals on the fourth day after operation.

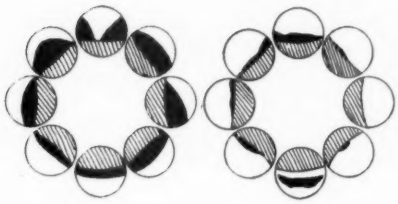

Fig. 39. Fig 41.

Fig. 30. Case 20. A triple lobe hypertrophy including the two lateral lobes joined by a considerably enlarged middle lobe.

Fig. 41. Case 21. Very slight hypertrophy of the right lateral lobe with a normal left lateral lobe. A definite enlargement of the subtrigonal or "Holmes" group of glands.

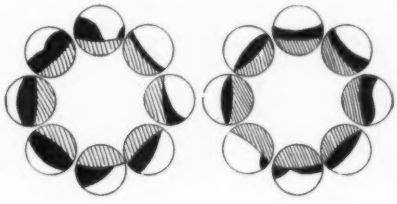

Fig. 43. Fig. 45.

Fig. 43. Case 22. A large right lateral lobe confluent with a large middle lobe. The left lateral lobe is only slightly enlarged.

Fig. 45. Case 23. Hypertrophy of both right and left lateral lobes. These join an enlarged middle lobe which is bifurcated.

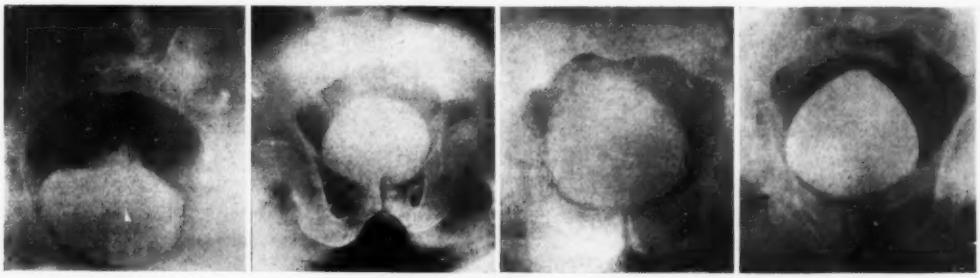

Fig. 42. Fig. 44. Fig. 46. Fig. 48.

Fig. 42. Case 20, roentgenogram No. 543. Cystogram taken 2 years and 4 months after operation. The bladder outline is somewhat oval and margins very irregular. The vesical orifice is smooth and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 425 cubic centimeters.

Fig. 44. Case 21, roentgenogram No. 522. Cystogram taken 2 years and 4 months after operation. The bladder outline is oval with margins regular. The region of the prostatic orifice is smooth and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 300 cubic centimeters.

Fig. 46. Case 22, roentgenogram No. 575. Cystogram taken 4 years after operation shows bladder outline round with margins quite regular. The region of the vesical orifice is smooth and shows no dilatation of the internal sphincter. Residual urine 0; bladder capacity 250 cubic centimeters.

Fig. 48. Case 23, roentgenogram No. 526. Cystogram taken 8 years after operation shows bladder outlines oval with margins regular. The vesical orifice is smooth and shows no dilatation of the internal sphincter. Residual urine 25 cubic centimeters; bladder capacity 525 cubic centimeters.

CASE 2. T. D.— B. U. I. No. 5025, 63–W. Complaint: frequency, urgency with some burning on urination.

Rectal examination. Prostate is apparantly not much hypertrophied— is about normal width. Median furrow and notch shallow. The right lobe is possibly a little indurated and adherent, otherwise negative. Left lobe is the same, no nodules and no tenderness made out.

Cystoscopy. Residual urine 300 cubic centimeters. Bladder capacity 800 cubic centimeters. Study of the prostatic orifice shows no cleft anteriorly. There is slight rounding of the right lateral lobe, which is continuous with a fairly pronounced median lobe as shown in chart. On the left there is a slight depression between it and the left lateral— the left lateral lobe—is only slightly larger than normal intravesically.

Operation. On exposing the prostate it was found to be small and no larger than normal. The usual two incisions were made into the capsule and two small pieces of nonhypertrophied tissue removed from each lateral cavity. The finger was introduced into the bladder and there was found a flat slightly irregular lobe lying on the trigone. This was freed with the finger and subsequently delivered into the left lateral cavity. The lobe was flat and definitely hypertrophied and rather firmly adherent to the bladder wall beneath. This was undoubtedly an Albarran lobe and did not communicate with the lateral cavities, there being no hypertrophy of the lateral lobes nor in the suburethral or median lobe.

Patient voided at intervals on the seventh day after operation.

CASE 3. W. B. F.— B. U. I. No. 5136, 53–M. Complaint: Retention of urine.

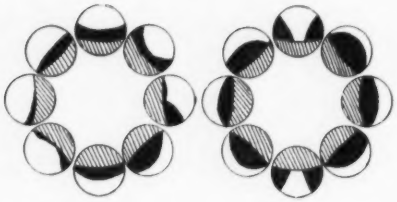

Fig. 47. Fig. 49.

Fig. 47. Case 24. An enlarged middle lobe with very slight involvement of the lateral masses.

Fig. 49. Case 25. Two large rounded lateral lobes with practically no middle lobe. The cleft at the site of the median portion was unquestionably caused by the previous Bottini operation.

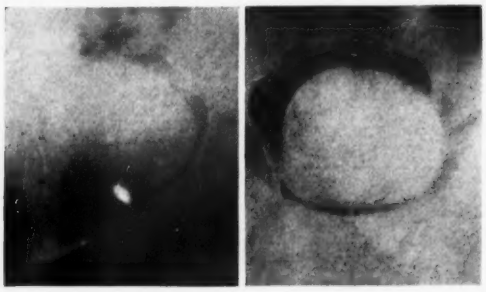

Fig. 50. Fig. 52.

Fig. 50. Case 24, roentgenogram No. 585. Cystogram taken 12 years after operation shows bladder outline round with margins regular. The region of the vesical orifice is smooth and shows no dilatation of the internal sphincter. Residual urine 20 cubic centimeters; bladder capacity 300 cubic centimeters.

Fig. 52. Case 25, roentgenogram No. 590. Cystogram taken 13 years after operation shows bladder outline oval and margins regular. The region of the vesical orifice is smooth and shows no dilatation of the internal sphincter. Residual urine 125 cubic centimeters; bladder capacity 425 cubic centimeters.

Rectal examination. On rectal examination the prostate is definitely enlarged, firm, elastic and bulges moderately into the rectum. It does not suggest malignancy.

Cystoscopy. Bladder capacity 200 cubic centimeters. The vesical orifice shows a very peculiar condition. On looking anteriorly there is seen a very deep cleft. The tissue to the left of this cleft is lobular, œdematous and at first sight makes one think there is present a tumor. This, however, is continuous with smooth tissue which is denser and evidently the median portion of the prostate. On the right the same condition is present but to less degree. The condition is evidently two large intravesical lateral lobes joined by a median commissure, due to the fact that the mucous membrane of the median portion is markedly depressed.

Operation. On making incisions into the posterior capsule the posterior lamella was comparatively thick but not indurated. The left lateral lobe was first freed and removed and then the right lateral lobe and with the right lateral was removed also, a broad, flat, adherent median lobe, which lay beneath the trigone. The specimen was removed practically complete in two pieces; one small piece was subsequently removed which was part of the median.

The patient voided at half hour intervals on the third day after operation.

CASE 4. A. G. L.—B. U. I. No. 5018, 60-M. Complaint: pain, burning on urination. Occasional hæmaturia.

Rectal examination. Prostate not markedly enlarged per rectum. Median furrow well marked. Right lateral lobe is rounded, smooth and elastic. No induration made out. The left lobe is the same.

Cystoscopy. Residual urine 75 cubic centimeters; bladder capacity 375 cubic centimeters. No cleft anteriorly. Right lobe is a little more prominent and a little more rounded than normal. There is unquestionably a rounded median bar which obscures the anterior part of the trigone. The left lateral is a little more rounded than normal and it is evident that the lateral lobes are hypertrophied. With the finger in rectum and cystoscope in urethra the median part is a little thickened. The lateral lobes are definitely hypertrophied.

Operation. Prostate freely movable not markedly enlarged. The left lobe was easily enucleated through the incision into the left lateral cavity. The right lobe was exposed in a similar way. This lobe was removed without difficulty. The median portion was then pushed into the cavity on the left side, this was dissected free and finally delivered through the left lateral cavity. Digital examination showed a slight thickening of the suburethral and subtrigonal portions. This was removed by means of a curette through the left lateral cavity. The internal sphincter was rather tight and was moderately dilated with the finger. The patient voided at intervals four days after operation.

CASE 5. C. M. B.—B. U. I. No. 5141, 63-M. Complaint: retention of urine.

Rectal examination. The prostate shows a moderate grade of hypertrophy. The left lobe is smooth and elastic somewhat adherent above and externally. The right lobe is also smooth and elastic and adherent above and externally. The median notch and furrow are practically obliterated. No areas of stony hardness.

Cystoscopy. Retention, bladder capacity 350 cubic centimeters. Study of the prostatic orifice shows a broad cleft anteriorly, some convexity of the left lateral margin down to position L at which point is seen a cleft as shown in the chart, and projecting from the left lateral margin in this region there is a large rounded mass which has a somewhat mottled surface and in places seems to be rather cystic. The median portion of the prostate is definitely elevated so as to obscure practically all of the

trigone. There is also hypertrophy of the right lateral lobe.

Operation. After incisions into the posterior capsule on either side of the midline a larger lateral lobe was shelled out from the left side, this lobe measured about 5x4x4 centimeters. A similar lobe from the right side, probably containing some median lobe was also enucleated. The sphincter was felt to contract tightly around the finger and there was no further prostatic tissue obscuring the orifice.

The patient voided at intervals on the fifth day after operation.

CASE 6. J. M. W.— B. U. I. No. 4876, 60-M. Complaint: retention of urine.

Rectal examination. Finger immediately encounters a soft bulging mass, surface smooth, contour rounded. The prostate is very soft, quite elastic. One reaches with difficulty the base of the prostate and there is considerable increase in the breadth of the prostate.

Cystoscopy. Examination of the vesical orifice shows a good sized intravesical enlargement. Directly anterior there is a shallow cleft with a very large right lateral which projects very markedly into the bladder, particularly anteriorly. The right lobe is continuous with the median, there being apparently no cleft separating the lateral from median portion. The left lateral lobe is distinctly enlarged, projects into the bladder as a rounded edge, but it is very much smaller than the right lateral.

Operation. The prostate was exposed without much difficulty, and was only slightly enlarged. The lateral lobes were enucleated each in two or three pieces, being small. The median portion came away partly through the left lateral with the assistance of the finger in the bladder.

Examination showed a well preserved sphincter, a very small lobule about as big as a pea on the left side which we did not succeed in removing.

Patient voided at intervals on the seventh day after operation.

CASE 7. H. G.— B. U. I. No. 4576, 67-M. Complaint: painful and frequent urination.

Rectal examination. Prostate is flat, a little broader than normal. Median furrow and notch shallow. The left lobe seems to be definitely hypertrophied, being lobular but small and enlargement is present. On the right side the lobe is flat and if there is hypertrophy present it is small. Both lobes are adherent externally, both moderately indurated.

Cystoscopy. Residual urine 50; bladder capacity 200 cubic centimeters. Shows slight rounding anteriorly with a very shallow cleft just to the left of the mid line. There is practically no intravesical enlargement of either lateral lobe and the median is not intravesically enlarged. Further study shows slight rounding of the median lobe which may account for the residual. With finger in the rectum and the cystoscope in the urethra there is considerable median thickening with definite collar around the beak of the cystoscope, so that the outlines of the beak cannot be definitely felt.

Operation. The lateral lobes were small and were removed with difficulty. The left was removed first. It was the larger of the two and measured roughly about 2x1x½ centimeters. The right was smaller and more adherent. Both were hypertrophied. Attempt was made to remove a suburethral portion which lay beneath the ejaculatory bridge. Difficulty was encountered because of fibrous adhesions and it was decided to cut through the ejaculatory bridge above. The suburethral portion was peeled off from the mucosa apparently without injury to it. This showed definite hypertrophy and was somewhat larger than the two laterals together. The ejaculatory bridge was stitched back in position.

Patient voided at intervals on the fifteenth day after operation.

CASE 8. E. C. W. — B. U. I. No. 4626, 47-M. Complaint: frequency of urination associated with pain and burning.

Rectal examination. Bladder evidently considerably dilated and presses well back toward the rectum. The prostate is pressed downward by the greatly distended bladder and is apparently not much hypertrophied. Median furrow and notch shallow. Right lobe is slightly irregular, moderately indurated but not much enlarged. Left lobe is similar to the right.

Cystoscopy. Residual urine 1125 cubic centimeters; bladder capacity not obtained. No cleft anteriorly. Right lateral lobe is not enlarged, middle lobe enlarged in the shape of a sessile, rounded intravesical hypertrophy of fairly considerable size and a deep sulcus on either side, as shown. Most of the trigone is obscured.

Operation. The prostate was easily exposed without injury to the triangular ligament, external sphincter or rectum. Posterior surface was only moderately larger than normal and the lateral lobes were small showing very little evidence of hypertrophy. The median lobe which came away through the right lateral cavity and through a rent in the urethra was about 3 centimeters in diameter, very adherent and entirely intravesical. The sphincter was somewhat dilated but not injured.

Patient voided at intervals on the ninth day after operation.

CASE 9. J. S.— B. U. I. No. 4613, 66-M. Complaint: retention of urine. Hæmaturia.

Rectal examination. Prostate moderately enlarged, smooth, elastic, moderately indurated, not nodular, slightly adherent on each side.

Cystoscopy. Retention. Residual urine 175 cubic centimeters. Study of the prostatic orifice looking anteriorly shows a globular lobe as the right which is apparently a right lateral which is rounded and moderately hypertrophied intravesically. The median lobe is irregular and projects well into the bladder with a shallow sulcus between it and the right lateral. The middle lobe projects more to the left and there is a fairly deep sulcus between it and the left lateral lobe which does not seem to be intravesically hypertrophied.

Operation. Prostate was moderately enlarged and was removed with some difficulty owing to the deep adhesions. The median portion of the prostate came away partly through the right and partly through the left lateral cavity. Examination then showed a sphincter somewhat dilated, no remaining enlargement present.

Patient voided at intervals on the third day.

CASE 10. J. D. P. — B. U. I. No. 4578. 59-W. Complaint: difficulty in urinating, hæmaturia and painful voiding.

Rectal examination. Prostate is much broader than normal, does not project much into the rectum. The right lobe is drawn outward and down and adherent, smooth, moderately indurated, particularly along the outer edge, no nodules, no tenderness. The left lobe is also moderately enlarged, smooth, elastic, firmer than normal, slightly adherent externally.

Cystoscopy. Retention. Bladder capacity 200 cubic centimeters. Orifice is a little irregular, no cleft anteriorly. The right lobe is slightly rounded but not much intravesically hypertrophied. The median portion of the prostate is elevated in the shape of a median sized, fairly globular lobe with a fairly deep sulcus between it and the right lateral. Left lobe obscured by blood, apparently not much intravesically hypertrophied.

Operation. Prostate moderately enlarged. The right lateral lobe was easily removed in one piece measuring 1½x2x3 centimeters. The left lobe came away in numerous small pieces, curette being required. Part of this lobe projected anteriorly in front of the urethra. The intravesical portion of the prostate came away in two pieces, one apparently a globular lobe projecting from the right into the bladder but probably median in character and the other pedunculated intravesical lobe which projected into the bladder apparently from the left side. Internal sphincter was dilated but apparently not torn.

Patient voided at intervals on the seventh day after operation.

CASE 11. W. L. F. — B. U. I. No. 4490, 78-W. Complaint: frequency, pain and burning on urination.

Rectal examination. The prostate is moderately enlarged. Median furrow and notch are shallow. The right lobe is moderately hypertropied. The left lobe of the prostrate is similar to the right, slightly indurated, globular, moderately adherent. There is nothing to suggest malignancy.

Cystoscopy. Retention. Bladder capacity 250 cubic centimeters. Study of the prostatic orifice shows no cleft anteriorly. On looking upward to the right a globular mass probably a middle lobe appears and this is seen directly to the right and also posteriorly. The median portion is elevated in the shape of a sharp thin elevated ridge which is continuous with the left lateral lobe as shown. The left lateral lobe and anterior margin are both quite hyperæmic. Further study of the globular lobe, which is evidently pedunculated and largely intra-urethral would seem to indicate that is more right lateral than median—though it is so movable that it is difficult to tell just where it springs up.

Operation. Prostate was easily exposed. The lateral lobes were moderately enlarged and each removed largely in one piece. Two or three small lobules were removed later. The median portion of the prostate came away with the deeper part of the right lateral and was about 2 centimeters in diameter. Examination showed a sphincter which was hardly at all dilated. There was no fibrosis about it.

Five days after operation patient voided at regular intervals.

CASE 12. H. M. — B. U. I. No. 4399, 63-M. Complaint: retention of urine.

Rectal examination. Prostate is very much broader than normal, presents a considerable grade of hypertrophy. The median furrow is almost obliterated. The right lobe is prominent, with a slightly irregular surface, very elastic, much more so than is usually found in these cases; laterally it is quite adherent. The left lobe is about the same size as the right, it is irregular over its surface and more indurated than on the other side, although it is quite elastic.

Cystoscopy. Bladder capacity 400 cubic centimeters. Study of the prostatic orifice shows a very wide cleft anteriorly. Both lateral lobes are about equally enlarged intravesically and continuous with a median which obscures practically all of the trigone. Except for the cleft anteriorly there are no other clefts made out.

Operation. Prostate moderately enlarged. The lateral lobes were removed each in one piece, and the median lobe measuring about an inch in diameter was easily removed through the right lateral cavity. Internal sphincter well preserved though dilated.

Patient voided at intervals on the nineteenth day after operation.

CASE 13. A. B. — B. U. I. No. 4304, 52-M. Complaint: painful urination with occasional retention and increasing frequency.

Rectal examination. Prostate is considerably enlarged. Median furrow and notch wide and shallow. Right lobe is slightly irregular, moderately indurated, in some places more than in others, nothing suggesting malignancy, no adhesions. The left lobe is larger than the right, quite prominent, considerably enlarged, moderately indurated but still elastic, slightly adherent externally.

Cystoscopy. Residual urine 0; bladder capacity 250 cubic centimeters. Study of the prostatic orifice shows a globular median lobe, somewhat duplex in character, and more closely associated with the right than the left lateral. The left lateral is not intravesically hypertrophied.

Operation. Prostate was difficult to expose owing to a great deal of bleeding and marked adhesions. The prostate was moderately enlarged and the lateral lobes were removed each in one piece, measuring about 2x2x3.5 centimeters. The middle lobe came away through the right lateral cavity, being

smaller, about 1.5 centimeter in size. Examination showed the vesical sphincter slightly dilated but otherwise uninjured.

Patient voided at intervals on the sixteenth day.

CASE 14. J. H. L.— B. U. I. No. 4249, 67-W. Complaint: difficulty in urination— irritability of bladder.

Rectal examination. Prostate is a great deal broader than normal. Median furrow and notch deep and wide. The right lobe is moderately enlarged, irregular moderately indurated, considerably adherent externally; induration not of stony hardness, compressible and elastic on deep pressure. The left lobe is smoother than the right, globular, moderately enlarged and indurated, compressible on deep pressure.

Cystoscopy. Residual urine 60 cubic centimeters; bladder capacity 250 cubic centimeters. No cleft anteriorly. Prostate is enlarged in the shape of a collar hypertrophy, consisting of fairly large median bar continuous without intervening sulci with the lateral lobes. There is a peculiar anterior lobe which lies to the right of the median line when the handle of the cystoscope is elevated. There is no enlargement of the left lateral lobe. The median portion of the prostate is considerably enlarged, elevated, well above the trigone, so that it is difficult to see the ureters.

Operation. The prostate was easily exposed without injury to the external sphincter or triangular ligament. It was markedly enlarged. The left lateral lobe was removed almost completely in one piece. The right lobe was smaller. It was removed in several small pieces. The median portion of the prostate came away in two portions through the right and left lateral cavities. Examination showed that the sphincter was well preserved.

Patient voided at intervals on the fourteenth day after operation.

CASE 15. W. E. — B. U. I. No. 4281, 69-W. Complaint: difficulty and frequency of urination.

Rectal examination. The prostate is a little broader and more prominent than normal. Median furrow and notch are shallow and broad. The right lobe is slightly enlarged, moderately indurated and adherent, not nodular, not tender. Left same as right.

Cystoscopy. Residual urine 40 cubic centimeters; bladder capacity 175 cubic centimeters. No enlargement of the lateral portions. The median portion is elevated in the shape of a small rounded bar with a shallow sulcus on each side, as shown. The right lateral lobe is not enlarged. The trigone is obscured in its anterior third by the median bar. With finger in rectum and cystoscope in urethra, the median portion of the prostate is only slightly thicker than normal, the lateral lobes are very little larger than normal and not markedly indurated.

Operation. The lateral cuts were made through the indurated tissue, the lateral lobes were covered with a few small spheroids each lateral lobe being very little larger than normal and not encapsulated as usual. Each came away in two or three small pieces measuring 1½x2x2 centimeters in size. The median portion was removed partly through the left and partly through the right lateral cavity. A slightly sclerotic sphincter was made out and dilated with the finger and also with the glove stretcher.

Patient voided at intervals on the twenty-seventh day after operation.

CASE 16. A. Y.— B. U. I. No. 4220, 66-M. Complaint: hesitancy, slight frequency and urgency.

Rectal examination. Prostate moderately enlarged, consistency elastic, no areas of marked induration felt. No stony hardness felt. The right lobe seems slightly more hypertrophied than the left. Off to the side of the left lobe are felt one or two small shot lime masses which are apparently glands. These, however, do not seem particularly hard. Median furrow shallow.

Cystoscopy. Residual urine 40 cubic centimeters; bladder capacity 450 cubic centimeters. Study of the prostatic orifice shows at once the presence of a large globular median lobe. There is no cleft anteriorly. The right lateral lobe is somewhat rounded and between it and the median is a cleft of moderate depth. The left lateral lobe is not intravesically hypertrophied but there is a cleft between it and the median lobe. The median covers the entire trigone obscuring both ureteral orifices. On looking directly posterior a small globular swelling apparently attached to the enlarged median can be seen, probably a small prostatic lobule or thick walled cyst.

Operation. A suburethral lobe, spherical in shape and measuring 1 inch in diameter was first discovered. It was brought into the right lateral cavity and enucleated without difficulty. Examination showed no lateral enlargement. A large subtrigonal median lobe, however, was found. This extended quite far anteriorly both on the right and left side, and was densely adherent. This was removed only after considerable difficulty. Examination of the vesical orifice now showed the complete removal of all obstruction.

Patient voided at intervals on the twenty-eighth day.

CASE 17. E. F. S— B. U. I. No. 4212, 76-W. Complaint: retention of urine.

Rectal examination. Prostate is moderately hypertrophied, placed rather high. It is smooth, elastic, symmetrical. Median notch and furrow obliterated. Somewhat adherent externally and above; no areas of stony hardness made out.

Cystoscopy. Residual urine 700 cubic centimeters; bladder capacity 225 cubic centimeters. Study of the prostatic orifice shows intravesical enlargement of the right lateral and median portion, being in the shape of a rounded globular median bar.

Operation. Two lateral lobes each measuring 1x¾x½ inches were removed from their respective cavities. Examination showed the presence of an intravesical median lobe which extended laterally well up on the right side. By manipulating the prostatic tractor this lobe was brought into the

right lateral cavity, its mucous membrane stripped off and the lobe removed without much difficulty.

CASE 18. M. F— B. U. I. No. 4176, 60-M. Complaint: Burning and frequent urination.

Rectal examination. Prostate high, moderately hypertrophied in both lobes, both are symmetrical, smooth and elastic. Median notch and furrow distinctly made out. Both lobes of prostate adherent externally and at either upper pole. There are thick bands of adhesions growing out to lateral wall of pelvis on the left.

Cystoscopy. Residual urine 25 cubic centimeters; bladder capacity 350 cubic centimeters. Study of the prostatic orifice shows a cleft anteriorly which contains a small lobule between the two lateral lobes. The rest of the prostate is hypertrophied in the shape of a collar which includes both laterals and median bars. No cleft between the lateral and median.

Operation. The right lateral lobe was first removed, it was very adherent and friable and came away in six small pieces, the weight of which was 9 grams. The left lobe, slightly larger than the right was next removed. Considerable difficulty was encountered here, owing to the gland being so friable, it was removed in five pieces and the total weight was 12 grams. The prostatic tractor was now removed and the finger introduced into the bladder through the urethra. It lay very deep, the tip of the finger just passing within the internal sphincter. The margins of the orifice were grasped with clamps and the structure pulled down into the wound. Examination showed the presence of a small middle lobe and also some tissue anteriorly. This was removed, the total weight of median and anterior portions being 4 grams.

Patient urinated at regular intervals on the twenty eighth day after operation.

CASE 19. R. H. B— B. U. I. No. 4111, 55-W. Complaint: urinary retention. Hæmaturia. Pain.

Rectal examination. Prostate enlarged and bulging per. rectum, left lobe elastic, regular in outline, moderately indurated and adherent. Right lobe is the same. Median furrow and notch shallow. Right lobe is somewhat larger than left and quite adherent externally.

Cystoscopy. Retention. Bladder capacity 600 cubic centimeters. Study of the prostatic orifice shows no cleft anteriorly. The right lateral is hypertrophied and between it and the median is a shallow cleft. The left lateral also enlarged though not as marked as the right, and is continuous below with the elevated median lobe.

Operation. Two lateral incisions were made. Prostate was very fixed in position, being very small. Right lobe removed and afterward the left and the median in one piece. Sphincter contracted well about the finger. The patient urinated at intervals on the fourteenth day after operation.

CASE 20. J. J. J.— B. U. I. No. 3795, 73-W. Complaint: frequency of urination, poor stream, nocturnal dribbling.

Rectal examination. Prostate is a peculiar small globular hypertrophy. Median furrow and notch shallow. The right lobe is larger than the left, quite prominent, smooth rounded elastic, but distinctly firmer than normal, few adhesions— no marked tenderness. Left lobe flat and probably broader than normal, smooth, firmer than normal, elastic, few adhesions, no nodules.

Cystoscopy. Residual urine 170 cubic centimeters; bladder capacity 310 cubic centimeters. Cystoscope shows a collar hypertrophy with a fairly large lateral lobe and median bar continuous with the two laterals elevated considerably above the trigone, the upper half of which is visible. Behind the trigone is a fairly deep pouch.

Operation. Two lateral incisions made one on each side of the ejaculatory bridge. Two rather large lateral lobes about 4x5 centimeters in size removed. A large median lobe was removed with the curette in two pieces. The internal sphincter was felt to be intact.

Patient voided at intervals on the fourth day after operation.

CASE 21. J. B.—B. U. I. No. 4388, 60-M. Complaint: frequency and burning on urination.

Rectal examination. Right lobe moderately hypertrophied, firm but not hard, very little evidence of hypertrophy. Left lobe about the same, but just to left of median furrow there is a hypertrophied spheroid about 1 centimeter in diameter moderately firm but not hard.

Cystoscopy. Residual urine 40 cubic centimeters; bladder capacity 300 cubic centimeters. Apparently not much hypertrophy except a thickening of the glands in the subtrigonal region, but with very little bar formation. No clefts seen. A marked rounding of the laterals.

Operation. Prostate was seen to be very small. Two lateral incisions made through the posterior lobe. A small spheroid was removed from each lobe and a median enlargement came away with the right lateral piece. The internal sphincter seemed to be greatly dilated.

Patient voided at intervals on the sixth day after operation.

CASE 22. G. W. S.— B. U. I. No. 3208, 66-M. Complaint: retention of urine.

Rectal examination. Prostate considerably enlarged, smooth, globular, uniform. Both lobes about equally enlarged. Consistency of the right lobe is distinctly firmer than normal, but still compressible; nowhere of stony hardness. Left lobe smaller, consistency being distinctly indurated but not of very marked degree. Upper end of prostate cannot be passed. Median furrow and notch shallow.

Cystoscopy. Residual urine 85 cubic centimeters; bladder capacity 600 cubic centimeters. Cystoscope rides up over a considerable median enlargement and the urethral length is greatly increased. Cystoscopy shows at once a very large right lobe projecting far into the bladder. Left lobe does not seem to be very much hypertrophied. Median lobe runs at

once into the right lateral lobe. Median lobe evidently in the shape of a bar.

Operation. Prostate was easily exposed. It was considerably enlarged and enucleated without difficulty, but apparently completely. The sphincters were apparently not injured.

Patient voided at intervals on the twentieth day after operation.

CASE 23. E. C.— B. U. I. No. 1174, 52-M. Complaint: frequency and burning of urination. Difficulty in starting stream.

Rectal examination. Prostate is considerably enlarged, much broader than normal. It is a little irregular, in places soft, at others hard, nowhere of dense induration. Median furrow and notch very indefinite. There are no adhesions, no tenderness.

Cystoscopy. Residual urine 230 cubic centimeters; bladder capacity 500 cubic centimeters. The cystoscope shows moderate enlargement of both lateral lobes and a large median lobe which is divided into two folds with a deep cleft between them as shown in the drawing. When the beak of the instrument is turned down and the shaft depressed you see the right lobe. The right portion of the median and the left portion of the median as shown.

Operation. Two incisions were made on each side of the urethra and two lateral lobes enucleated with the finger— a small median lobe was also removed in this case.

Interval urination started on the fifth day.

CASE 24. M. R— Gen. No. 16296, 54-M. Complaint: retention of urine.

Rectal examination. Prostate much enlarged and bulging posteriorly into rectum. Symmetrical— fairly hard, not tender. Palpating finger cannot reach over it.

Cystoscopy. Cystoscopy attempted, but unsatisfactory on account of sharp hæmorrhage from prostatic urethra. With cystoscope in the urethra and finger in the rectum the median mass is found to be quite considerable.

Operation. The two lateral lobes were pressed out through the incision by blunt dissection. Median enlargement was turned to the right and pressed out last.

Patient voided at intervals on the twenty-first day after operation.

CASE 25. W. F. S— B. U. I. No. 173, 55-M. Complaint: retention of urine.

Rectal examination. Prostate considerably enlarged and both lateral lobes and median furrow is broad. Notch at upper end obliterated. Lateral lobes bulge moderately toward the rectum but their upper ends can be easily reached by finger; consistence, soft, elastic, contour smooth and no nodules present.

Cystoscopy. Cystoscope shows a large rounded intravesical outgrowth from each lateral lobe; between these two the urethra is compressed laterally, and with the cystoscope looking downward a narrow chink is seen between the two enlarged lobes in the urethra. Superiorly the lobes do not press together so tightly. The left lobe is larger and projects farther into the bladder than the right. In the median portion there is a thin fold of mucous membrane which connects the two lateral lobes. The hypertrophy therefore consists of two bulging lateral lobes which compress the urethra between them.

Operation. The capsule was divided on either side of the median furrow by means of blunt dissection and the finger; the enormously hypertrophied lateral lobes of the prostate were stripped out. Each lobe seemed lobulated and was removed in several pieces, each piece in turn being drawn into the wound by aid of the tractor and stripped out. The lobes were very adherent to the bladder mucosa where the Bottini operation had been previously done.

Patient voided at intervals on the thirteenth day after operation.

SUMMARY OF CASES

1. G.M.G.— B.U.I. No. 5237. Cystogram No. 608, 3 weeks after operation. Internal sphincter closed.
2. T.D.— B.U.I. No. 5025. Cystogram No. 536, 3½ weeks after operation. Internal sphincter closed.
3. W.B.F.— B.U.I. No. 5136. Cystogram No. 585, 3½ weeks after operation. Internal sphincter closed.
4. A.G.L.— B.U.I. No. 5018. Cystogram No. 530, 4 weeks after operation. Internal sphincter closed.
5. C.M.B.— B.U.I. No. 5141. Cystogram No. 605, 5 weeks after operation. Internal sphincter closed.
6. J.M.W.— B.U.I. No. 4876. Cystogram No. 588, 4 months after operation. Internal sphincter closed.
7. H.G.— B.U.I. No. 4576. Cystogram No. 498, 5 months after operation. Internal sphincter closed.
8. E.C.W.— B.U.I. No. 4626. Cystogram No. 515, 6 months after operation. Internal sphincter closed.
9. J.S.— B.U.I. No. 4613. Cystogram No. 570, 8 months after operation. Internal sphincter closed.
10. J.D.P.— B.U.I. No. 4578. Cystogram 540, 7 months after operation. Internal sphincter closed.
11. W.L.F.— B.U.I. No. 4490. Cystogram No. 607, 10 months after operation. Internal sphincter closed.
12. H.M.— B.U.I. No. 4399. Cystogram No. 523, 11 months after operation. Internal sphincter closed.
13. A.B.— B.U.I. No. 4304. Cystogram No. 517, 13 months after operation. Internal sphincter closed.
14. J.H.L.— B.U.I. No. 4249. Cystogram No. 511, 14 months after operation. Internal sphincter closed.
15. W.E.— B.U.I. No. 4281. Cystogram No. 563, 14 months after operation. Internal sphincter closed.
16. A.Y.— B.U.I. No. 4220. Cystogram No. 544, 15 months after operation. Internal sphincter closed.
17. E.F.S.— B.U.I. No. 4212. Cystogram No. 573, 16 months after operation. Internal sphincter closed.
18. M.F.— B.U.I. No. 4176. Cystogram No. 679, 20 months after operation. Internal sphincter closed; Cystogram No. 508, 14 months after operation. Internal sphincter dilated.
19. R.H.B.— B.U.I. No. 4111. Cystogram No. 525, 21 months after operation. Internal sphincter closed.
20. J.J.J.— B.U.I. No. 3795. Cystogram No. 543, 2 years 4 months after operation. Internal sphincter closed.
21. J.B.— B.U.I. No. 4388. Cystogram No. 522, 2 years 4 months after operation. Internal sphincter closed.
22. G.W.S.— B.U.I. No. 3208. Cystogram No. 575, 4 years after operation. Internal sphincter closed.

23. E.C.— B.U.I. No. 1174. Cystogram No. 526, 8 years after operation. Internal sphincter closed.
24. M.R.— Gen'l. No. 16296. Cystogram No. 585, 12 years after operation. Internal sphincter closed.
25. W.F.S.— B.U.I. No. 173. Cystogram No. 590, 13 years after operation. Internal sphincter closed.

SUMMARY

From a study of the cases herewith reported it is seen that following perineal prostatectomy the internal or vesical sphincter returns to its normal tone and function in every instance. This takes place within a few weeks as demonstrated by the accompanying cystograms. From clinical observations we are led to suspect an even earlier return of function judging from the establishment of definite intervals of urination a few days after prostatectomy has been performed with a perineal urethrotomy in the membranous urethra back of the internal sphincter as it should be. Not infrequently urine is voided at three and four hour intervals at this period both through the urethra and through the urethrotomy wound, while during the intervening time the patient is perfectly dry. These rather long periods of complete continence could not occur under the above conditions if the vesical sphincter were not functioning normally.

One interesting case, 18, in which the vesical sphincter was found closed and functioning normally twenty months after operation (cystogram No. 679), at an earlier examination fourteen months after operation was found to be dilated (cystogram No. 508), with the posterior urethra funnel-shaped and virtually forming a part of the bladder cavity. During this time the patient had periods of incontinence which, however, had entirely disappeared at his last examination. In referring to the operative note in this case it is seen that the operator states of the vesical orifice: "— it lay very deep, the tip of the finger passing just within the internal sphincter. The margins of the orifice were grasped with clamps and the structure pulled down into the wound." This procedure undoubtedly injured the sphincter to a degree sufficient to account for the long delay in its restoration of function. It is of interest to note in this instance, however, that even after an interval of over a year there was complete recovery of function and anatomical relationship.

My thanks are due Hugh H. Young, director of the James Buchanan Brady Urological Institute, for his kindness in placing the above material at my disposal, and to Charles A. Waters of the Department of Roentgenology for his painstaking care in making the roentgen plates.

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THE ACUTE ABDOMEN[1]

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THE acute abdomen might seem a subject, upon which, at the present time, but little remains to be said; but increasing experience seems to justify its careful consideration and division into two classes as follows:

1. Those that may be remedied by abdominal operations.

2. Those that may not be remedied by abdominal operations.

The first class is, of course, in the majority; as a general rule, it does not necessitate differential diagnosis, as it makes no difference to the patient, and it makes no difference in the first steps of the treatment, whether the cause of the trouble is a ruptured appendix, a perforation of a gastric or duodenal ulcer, a cholecystitis or one of the many other causes of such symptoms, as long as the condition is remediable by an operative procedure, subsequent to laparotomy. The symptoms call for exploratory laparotomy which is automatically followed by the proper diagnosis and in turn rational therapeusis. In such cases the problem is absurdly simple, and the fate of the patient rests not so much with the operator who repairs the lesion as with the physician who first sees the case, and suspects serious damage.

The repair of reparable damage of the abdominal viscera (granting the presence of surgical judgment on the part of the operator) is comparatively simple; on the other hand the cure of peritonitis, the result of such damage, is difficult.

This class of cases, comprising the majority of abdominal emergencies, will not be discussed, because the principles of treatment are well outlined, and the conditions are recognized and discussed freely in textbooks and current literature.

The second class demands attention, serious consideration, and emphasis, because these conditions are but rarely differentiated from class 1, with the resultant ineffectual, if not detrimental, line of treatment. The lesions may be divided into (1) extraperitoneal which may simulate intra-abdominal disease; and (2) intraperitoneal (non-operable) which may simulate operable conditions.

The extraperitoneal lesions may include thoracic, retroperitoneal, nervous, and others.

THORACIC LESIONS

Pneumonia. Confusion between the early stages of pneumonia and acute appendicitis is not so uncommon as might be expected. The general statement is frequent that pneumonia may, in its early stages, be mistaken for acute abdominal complaints, but detailed reports of such instances are not frequent. Some cases of pneumonia, after operation for acute appendicitis, in which the operative findings are not quite characteristic, might possibly have been cases of obscure and undetected pneumonia, before operation. Postoperative pneumonia should be lobular not lobar.

One of the reasons for this confusion is that often during the first 24 hours of pneumonia the pulmonary symptoms and physical signs in the chest may be entirely absent.

Pneumonia of the right lower lobe can, especially in children, by irritating the tenth, eleventh, and twelfth intercostal nerves produce pain, rigidity and tenderness in the right side of the abdomen which accompanied by the fever, leucocytosis and vomiting of the pneumonia will closely simulate an acute appendicitis.

In pneumonia, the abdominal tenderness is less characteristic and usually situated higher, the resistance is less marked but may be the same as in appendicitis. On the other hand severe inflammation of the appendix may cause diminution of the respiratory excursion and in the breath sounds of the right lower lobe, in this way tending to make the diagnosis still more difficult.

The important point is to *think* of the possibility of pneumonia giving rise to the symptoms in question, notably in children

[1] Read before the Scranton Academy of Medicine, March, 1917.

with rapid respiration and pulse. high temperature and dilatation of the alæ nasi. Such symptoms call for a careful chest examination, not confined to the *anterior* aspect. In most cases, such an examination settles the diagnosis.

Diaphragmatic pleurisy. Capps has found that the *visceral* pleura is not sensitive to pressure or scratching of a wire, that such irritation of the *parietal* pleura produced pain, but that irritation of the outer margin of the diaphragmatic pleura supplied by the lower six intercostal nerves is followed by reflex pain in the hypochondrium, and often in the abdominal wall as far down as the navel or even the groin, and when the central portion is irritated the pain is referred by the phrenic to the neck by the third and fourth cervical nerves. Capps presents a study of 61 cases of diaphragmatic pleurisy: 39 of right side, 21 left side, 1 bilateral, in which referred abdominal pain occurred in 54 cases and there was referred neck pain in 33 cases or about 50 per cent.

While aspirating fluid from the pericardial sac in a recent case I was able to cause pain in the left side of the neck by irritating the lower portion of the pericardial sac.

The following 23 mistaken diagnoses were made in the series of 61 cases of diaphragmatic pleurisy: 9 appendicitis, 6 cholecystitis, 2 perforation of ulcer of the stomach, 2 liver abscess, 1 peritonitis, 1 renal calculus, 1 infectious lumbago, and 1 brachial neuritis.

Capps' conclusions are as follows:

The skin and muscles of the abdomen are more sensitive to pain in referred pleural pain than in visceral disease. This is best elicited by the pinching of the wall and the scratching of the skin.

The cutaneous reflexes are more lively in referred pain than in visceral disease, as a rule.

Deep pressure, with the flat surface of the fingers, is well borne in referred diaphragmatic pleural pain, while it elicits a dull, deep pain when applied over an inflamed organ, e.g., an appendix or gall-bladder.

Evidences of respiratory infection are usually present in diaphragmatic pleurisy; such as a cough, expectoration, herpes of lips, sore throat, high leucocytosis, rapid respiration, etc.

Appearance of a sharp, definitely localized pain in the neck, on the same side as the abdominal pain, often reveals the true condition, since it points to irritation of the phrenic nerve.

The referred pain in the neck and abdomen are usually induced, or aggravated, by cough and deep respiration.

Nausea and vomiting are more constant in visceral abdominal inflammation, but may be pronounced in diaphragmatic pleurisy.

Hiccough is not a common symptom in diaphragmatic pleurisy contrary to the current belief. It was present only 5 times in 61 cases. It is more often seen in visceral disease of the abdomen than in diaphragmatic pleurisy.

CARDIAC LESIONS

Angina pectoris is characterized by epigastric pain after eating or after exertion, and is relieved by belching; because of these characteristics the milder types of the disease are frequently mistaken for attacks of acute indigestion, and more rarely, and under rather unusual conditions, the more severe attacks may be confused with acute abdominal conditions. In angina pectoris the pain is due to exertion, not food, the blood pressure is usually high, and the heart rarely normal. The attack is accompanied by great fear or apprehension of approaching death. The pain is usually referred to the left arm, but may be referred to the back, epigastrium, testes, leg or right arm.

The appearance of the facies is characteristic, the features are sunken, the face pale and cold, with an expression of agony, anxiety, and distress, quite similar, on superficial examination, to the "facies hippocratica."

Emphasis should be laid on the resemblance of some of these cases to surgical accidents. The sudden onset, with pain over the lower sternal and epigastric region, the nausea and vomiting, the tympany, the feeble pulse, ashy color, cold sweat and other signs of collapse, make one think of certain acute abdominal conditions.

Where there is arteriosclerosis, enlarged heart, a history of previous angina, typical radiation of the pain in the neck and arm, the diagnosis will not be so difficult as where these suggestive aids are lacking.

Pericarditis. In acute pericarditis the symptoms are those of an acute infection. The disease is characterized by pain in the region of the heart. This pain may be referred to the abdomen, to the region of the stomach, gall-bladder, or appendix. A careful examination will usually reveal tumultuous heart

action: dyspnœa, cyanosis, dysphagia, friction rub, and with effusion, enlarged cardiac dullness. Fluoroscopic examination is of great value.

Fussell has seen pericarditis mistaken for appendicitis, but states that the mistake rarely occurs in the reverse way. (I have been called to operate upon a case for cholecystitis in which the examination revealed a pericarditis with friction rub.)

RETROPERITONEAL LESIONS

Renal. Among the renal conditions that might be confused with intra-abdominal lesions should be mentioned (1) stone, (2) Dietl's crises, (3) unilateral hæmatogenous infection of the kidney, the septic infarct of Brewer, (4) uræmia, (5) perinephritic abscess, and (6) pyelonephritis. The most frequent is stone. Renal colic is characterized by severe pain, usually calling for morphine, with tenderness in the loin, and vesical tenesmus, with nausea or vomiting and hæmaturia, with no increase in temperature or leucocytosis. The symptomatology of renal lithiasis has been very exhaustively studied by Braasch, who found great variations in the usually accepted signs and symptoms. For example, typical pain and tenderness in the kidney region was present in only 117, of 251 cases: in 26 pain was general abdominal; in 30, pain referred to gall-bladder; in 32, pain referred to lower abdomen; in 56, pain referred to both sides of abdomen; in 40, pain referred to affected sides of abdomen; in 16, pain referred to non-affected side of abdomen. Thus one is justified in concluding that the pain of renal lithiasis may be very atypical.

Braasch, likewise found that hæmaturia was present in 141 of 251 cases, or 56 per cent, a rather indefinite percentage, and, to make matters worse, in 500 consecutive routine examinations in cases without symptoms of renal trouble, 146 showed microscopic blood in the urine.

Cabot, in 150 cases of renal and ureteral stone, found the urine persistently normal in 14 per cent, hæmaturia absent in 32 per cent.

The presence of microscopic blood in the urine may be due to pathology in any part of the genito-urinary tract. The mere fact that there is an acute abdominal inflammation may cause microscopic hæmaturia.

The contact of an acutely inflamed appendix with the ureter or bladder may give rise to blood in the urine. Eising reports two such cases of pericystitis complicating acute appendicitis, and I have seen two cases in which symptoms suggestive of appendicitis, with a mass in the pelvis, were relieved by the removal of bloody urine from the distended bladder. Laparotomy disclosed a gangrenous appendix in contact with the fundus of the bladder.

Such cases are not uncommon, and too much stress must not be placed upon the presence of a few red blood-cells in the urine, as indicative of renal colic.

The X-ray failed to reveal urinary calculi in 10 to 15 per cent of Cabot's and in 11 per cent of Braasch's cases.

Confusion between abdominal conditions and kidney stone was emphasized by the late Maurice Richardson who wrote an extensive article, the last before his death, on "The Error of Overlooking Ureteral Stone Under a Diagnosis of Appendicitis," and Hugh Cabot reported 157 cases of stone in the kidney and ureter, in 26 of which unnecessary abdominal operations had been performed. These operations were distributed as follows:

Appendectomy without relief	10
Exploratory laparotomy	7
Fixation of kidney	4
Operation for gall-stones	1
Decapsulation of kidney	1
Salpingo-oophorectomy	1
Suprapubic cystostomy	1
"Adhesions"	1
	26

And in a recent contribution, Braasch states that 143, or practically one-third of the total number in his series of cases of nephrolithiasis had had previous laparotomies performed elsewhere for relief of pain: 83 with stone in right kidney; 55 with stone in left kidney; 5 with stone in both kidneys; twenty-one patients with stone in left kidney had had previous operations on the appendix or gall-bladder.

Dietl's crises is characterized by symptoms that simulate renal colic, or intra-abdominal

disease, such as severe abdominal or lumbar pain, nausea, vomiting, distention, rigidity, with enlarged tender kidney, and variable bladder symptoms with a usual absence of temperature and leucocytosis. This condition is supposed to be due to an acute obstruction of the ureter by kink or torsion of a floating or wandering kidney. It was first described by Dietl in 1864, and its frequency is decreasing with more painstaking examination and more accurate diagnosis.

Acute hæmatogenous infection of kidney, acute septic infarct of kidney. Brewer, in 1906, analyzed 13 cases, and found 11 in women and 11 on the right side. Chill at onset was present in 4. Sudden high temperature, 104°, at first examination was found in 12. In three cases there were marked remissions; in others, the temperature was constantly high. In all cases the pulse was rapid, over 120. In 12 the chief complaint was abdominal pain, in 4 in the right iliac region. The costovertebral angle was tender in all. Muscular rigidity was a frequent finding as was leucocytosis. Microscopic blood was found in the urine of all but one.

In these cases, with the sudden onset, severe general pain, localizing on the right side, vomiting, with profound constitutional toxic disturbances and few definitely renal symptoms, the condition is often mistaken for intra-abdominal infection.

In Brewer's 13 cases, an abdominal incision, under mistaken diagnosis, was made three times. In Cobb's 8 cases, the same mistake was made in 3 instances.

That this type of case is not as uncommon as was previously supposed, is shown by the fact that Mason in 1912 collected 28 cases, and Cunningham in the same year reported 8 additional cases.

In a personal case, 2 days after an unsuccessful abdominal operation, nephrectomy was followed by a satisfactory outcome.

Disease of the suprarenal capsule. Addison's disease, or syndrome, is characterized by (a) physical and mental inertia, (b) pigmentation, (c) gastro-intestinal symptoms.

In the last we find anorexia, nausea, vomiting, constipation and later diarrhœa, enteroptosis, pain in lumbar and iliac regions, with slight rigidity and tenderness on palpation in right iliac fossa, which may, at times, be attributed to intra-abdominal disease.

Study of the suprarenal gland has taught that there is a *cortical* portion that concerns the sexual function; and a *medullary* portion that seems to have a double function; one concerning pigmentation, and the other, in the production of suprarenin or adrenalin. This medullary portion consists of connective tissue, nerves and cells, the most important is the chromaffin cell. This chromaffin is found in the medullary portion of the adrenal, in the sympathetic ganglia, in the substance of the epididymis, and all these combined constitute what is known as the chromaffin system, which seems in some way, as yet not understood, to be intimately connected, either as a hypo- or hyper-function, with these atypical abdominal complaints.

Addison's syndrome, because of the gastro-intestinal symptoms, in which the pain at times may be severe, may be confused with intraperitoneal disease.

The symptom-complex characteristic of Addison's syndrome is not uncommon. The pigmentation will be found very frequently with the other two, if it is intelligently looked for. One meets this syndrome frequently in cases that come under observation with a diagnosis of chronic appendicitis, but one hesitates to diagnose Addison's disease.

That there may be *acute* pain in this class of cases is beyond question; and Tice cites a case in point. The diagnosis of Addison's syndrome and *appendicitis* was made. In a "subsequent note" it is stated that there was exacerbation of the appendicitis which led to transfer to the surgical service and laparotomy was performed, at which the findings were negative, except for "an old adherent appendix" which was removed. Death occurred the following day and an autopsy was not permitted. This "exacerbation of the appendicitis" was evidently a misinterpretation of the symptoms.

Brodnitz calls attention to the "violent intestinal colic occurring in attacks, failure of the peristalsis, and isolated intestinal distention." And Ebstein says that in the terminal stages there is excessive vomiting,

abdominal pain and constipation, the abdomen is retracted and the walls tense, the pulse becomes small and there exists *in toto*, the picture of peritonitis.

Hæmorrhage, or suppuration, may lead to sudden destruction of the suprarenal glands. This condition is but rarely recognized, was first described by Virchow, and is characterized by very severe symptoms together with peritonitis which ends rapidly in death.

Uræmia. In certain cases of uræmia, acute abdominal pain, distention, with severe vomiting and fever may be present. Differential points are urine examination, blood pressure, hypertrophy of heart.

The acute abdominal pain of nephritis particularly of the hæmorrhage type, has been emphasized by Osler.

Perinephritic abscess. Perinephritic abscess may simulate peritoneal disease, but careful history and examination will usually prevent confusion.

Pyelonephritis. Pyelonephritis is undoubtedly a cause of pain in the right side of abdomen, that may lead to erroneous diagnosis. In 90 cases of proved pyelonephritis entering Cook County Hospital, in 1917, Culver found that the entrance diagnosis included almost every possibility. In two personal cases in which symptoms persisted after appendectomy, catheterization of the ureter showed a pyelitis of the right kidney.

Genito-urinary tract in the male. Inflammation of the epididymis, prostate gland, or the seminal vesicles may cause pain and tenderness in the right iliac fossa, as likewise may small hernia.

Orthopedic conditions. Orthopedic conditions such as caries, spondylitis deformans or hypertrophic arthritis of the vertebræ, subluxations of the sacro-iliac or lumbosacral articulations, or the presence of an abnormal transverse process of the fifth lumbar vertebra, are all of importance in a consideration of atypical abdominal pain. They usually give rise to chronic symptoms but, occasionally may cause acute pain, and other symptoms that may simulate intra-abdominal lesions. They may be suspected by limitation of motion of the spine, with local tenderness over vertebræ or lumbar regions.

R. C. Cabot reports 17 cases of vertebral tuberculosis (Pott's disease) that came to autopsy; only 4 were recognized in life. He says that knuckle in the spine, pressure signs, muscular rigidity, limitation of motion, and secondary abscess are not common.

The important diagnostic point is X-ray examination which may show erosion, arthritis or deformity; but these roentgenograms must be given careful study before arriving at conclusions, as the normal X-ray picture is not yet definitely accepted.

Cotton in a very concise article on "Fractures of the Transverse Processes of the Vertebræ," makes the statement that, "within a year a certain amount of loose literature has appeared concerning fractures of the transverse processes of the vertebræ. It does seem to me that we should refrain from diagnosis, or at least from prognosis and cures, and even from expert testimony until we have more facts."

In 22 cases classed as fracture of the transverse process of the vertebra, in the X-ray Department, of the Boston City Hospital, Cotton was able to find a fracture in only 12, and after briefly abstracting these cases and presenting outline drawings of the roentgenograms in 6, of which the traumatic origin was doubtful, concludes that "anomalies in this region are frequent; often ill shown by average routine X-ray plates, are not always properly interpreted, and are apt to be called fractures.

"More than that, it is suggested that real fractures of the transverse processes may not improbably unite by fibrous union without persistent symptoms, and be chanced on later.

"There is no doubt that real fractures of the transverse processes of the vertebræ in the lumbar region do occur; probably not very infrequently. How important they are, does not yet appear, nor will their importance be manifest until other series are studied, and some of them carried on, to investigation of end-results."

Subperitoneal or retroperitoneal cellulitis or infection. Acute abdominal pain in the right lower quadrant, rapidly spreading and becoming general, with tenderness, rigidity,

increased pulse rate, elevation of temperature often with a chill and leucocytosis, during the course of an attack of influenza with pharyngitis or tonsillitis, may be streptococcal infection of the subperitoneal areolar tissue, secondary, or metastatic, to a primary focus in the pharynx or tonsil, in which the appendix is invaded merely as an incident in the course of the general infection. As the appendix, in these cases, is not a causative factor its removal will have but little influence upon the course of the disease. Such cases call for careful differentiation; if they are retroperitoneal streptococcal infections, appendectomy is not of much avail. Many such cases continue to death after operation by general bacteræmia, pneumonia or nephritis.[1]

As radical an operator as Murphy was, he advocated a non-operative treatment, noting that such cases fared better without operation, that the resistance of the patient was lowered by futile operation, and that a fatal termination was liable to follow instead of cure. He says: "The greatest stress should be laid on the differential diagnosis between intra- and subperitoneal infections, and in addition, the fact should be forced on the profession that subperitoneal cellulitis is not in the range of operative treatment, and that the proper treatment of intraperitoneal peritonitis is, primarily, a surgical one. Cases of subperitoneal cellulitis are not remedied at all by opening and draining of the peritoneal cavity, as this does not attack the field of infection, namely the subperitoneal cellular tissues."

Anderson cites a number of cases of acute appendicitis as a sequel of tonsillitis and he emphasizes the fact that this type of case is prone to be atypical.

A personal case of this type, in abstract, is as follows:

A. R., servant, female, single, age 17 years. The patient had always had "stomach trouble" but it was never sufficiently severe to warrant consulting a physician.

On April 9, 1911, she had tonsillitis, with the usual symptoms; onset of menses the day before. On April 11, she had pain, swelling and tenderness of the right knee. On April 12, the knee became worse and she had the same symptoms in the right ankle and both wrists, which necessitated her ceasing work, going to bed and calling a physician. Dr. Neil Andrews made a diagnosis of polyarthritis secondary to tonsillitis. On April 13, the joints improved, but she complained of abdominal pain, nausea and vomiting. These symptoms with temperature persisted and on April 16, the pain and tenderness in the abdomen became localized in the right iliac fossa. Examination revealed tenderness and rigidity of right rectus. The thigh was flexed and extension caused pain in the right iliac fossa. Pulse 130 and temperature 103° F. Leucocytosis 20,000. Diagnosis: acute appendicitis.

Operation revealed visceral and parietal peritoneum congested, blistered, swollen, œdematous; straw colored free fluid; pelvic and abdominal viscera negative; appendix congested, similar to other peritoneum with no adhesions, mesenteriolum infiltrated, mesenteric glands enlarged and a pericolic membrane. Typical appendectomy was performed, followed by the closure of the abdomen without drainage.

The convalescence was very stormy; for four weeks the temperature remained high, with elevation to over 103° F. with new joint manifestations. The abdominal wound healed *per primam*. Since then the patient has been in perfect health, and examination in December, 1916, confirmed the report. In my opinion the recovery in this instance was in spite of, and not because of, the removal of the appendix.

J. S. Evans presents the result of observation upon the relationship between pyogenic infections of the upper respiratory tract and the morbidity curve of acute appendicitis, during fifty-nine months, among the students of the University of Wisconsin and evidently encountered no such cases. During this period there were 236 cases of acute appendicitis in over 16,000 students, 214 of which were primary attacks. In 86 per cent there were observed definite primary infections of the upper respiratory tract. The primary respiratory infection preceded the acute appendiceal attack on an average of 16 days, the minimum interval being 1 day, the maximum 60 days.

In studying the morbidity curve of appendicitis from month to month we find that at eight periods during the six years there were marked increases above the expectant rate. Since similar increases above the expectancy of acute upper respiratory infections attended these same periods, we consider the evidence

[1] The above was written before the recent pandemic of influenza and subsequent experience has seemed to emphasize the importance of this point.

of an etiologic relationship between the two diseases the more definite. The total number of cases in these eight periods was 113 and the total number of days involved was 226, or an average of one case of appendicitis every two days. This is in such sharp contrast to both the average monthly rate and to the expectant rate for each of the 59 months that one is justified in considering each group of cases as a definite epidemic.

Evans suggests: "In this group of 113 cases we were dealing with micro-organisms of the streptococcus group possessing a definite tropism for the appendix."

The condition of subperitoneal inflammation subsequent to puerperal infection of the uterus, and designated as "dry-peritonitis," has been recognized for some time.

Peritoneal operations and radical procedures in such circumstances have been so unsatisfactory that they are no longer considered, and conservative measures are now indicated.

Enlarged mesenteric lymph glands, usually tubercular, as in "tabes mesenterica" or abdominal Hodgkin's disease, in the right iliac fossa at the lower end of the root of the mesentery, may be palpable through the abdominal wall. Such a finding on palpation, in conjunction with acute abdominal symptoms and temperature may lead to confusion with an acute appendicitis.

Carson, in a consideration of "The Clinical Aspects of Tuberculous Mesenteric Glands," recommends the removal of any caseating or calcareous glands, which he admits may be rather a tedious procedure; and that it is not devoid of danger is shown by a personal case.

Exploratory laparotomy was performed upon a child of 6 years with a temperature, right iliac mass, pain and tenderness, and a history of so-called "chronic appendicitis," to settle a diagnosis of tuberculosis or appendicitis. At operation the appendix was found to be normal and was not removed. The mesenteric lymph glands were enlarged and one was removed for diagnosis. This was followed by meningitis and death.

Enlarged mesenteric lymph glands are frequent in cases of so-called chronic appendicitis, but in a careful histologic study of many such glands, I have been unable to find any evidence of tuberculosis.

NERVOUS LESIONS

In a study of *abdominal* pain, it may be of interest to make a comparative review of pains within the *cranial* cavity.

According to Fussell, headaches may be due to (a) reflex irritation; (b) toxæmia, infectious or chemical; (c) circulatory disturbances; (d) neuroses; (e) organic diseases of the brain, its membranes, or skull (the brain is insensitive and pain is due to involvement of the meninges either actually or by pressure); (f) indurative or muscular, due to the pressure of rheumatic nodules in the muscles of the scalp or neck; (g) neuralgia or neuritis.

With this formidable and confusing array of possible causes of pain in the head, one might well pause and consider before jumping at a conclusion without careful investigation of the possibilities in cases of pain in the abdomen.

The nerves of the abdominal wall are as follows: anterior divisions of the lower six intercostal (dorsal) nerves, called the abdominal intercostals. (The twelfth dorsal is larger and communicates with the iliohypogastric branch of the first lumbar, and the hypogastric branch of the first lumbar nerve.)

The *twelfth dorsal* nerve leaves the spinal canal below the last dorsal vertebra and rib, running at first behind the psoas muscle and in front of the quadratus lumborum. It pierces the transversalis and passes between it and the internal oblique, *two inches above the iliac spine*, in a downward and inward direction to the edge of the rectus, where it pierces the sheath and runs behind it to about the middle of the belly of the muscle. It pierces the muscle and the anterior rectus sheath, some branches becoming cutaneous and supplying the skin below the umbilicus. It also supplies branches to the transversalis, the internal and external oblique, the rectus and the pyramidalis muscles.

The *hypogastric branch* of the first lumbar nerve, runs between the transversalis and internal oblique, *about an inch above the crest of the ilium*; it continues downward and inward parallel to the twelfth dorsal, pierces the internal oblique about an inch in front of the anterior superior iliac spine and lies about

half an inch above the inguinal canal under the aponeurosis of the external oblique; pierces the aponeurosis of the external oblique an inch and a half above the external inguinal ring, becomes cutaneous, and supplies the skin above the pubes below the level of the twelfth dorsal. It gives off branches to the transversalis, oblique, and pyramidalis muscles.

Neuritis and neuralgia. Neuritis and neuralgia are differentiated clinically, but most neuralgias are probably due to a mild perineuritis.

In neuralgia, the pain is sharp shooting and paroxysmal limited to the course of a nerve, and is made worse by peripheral irritation. In neuritis, the pain is constant, burning or boring, and worse at night; with tenderness over the course of the affected nerve and aggravated by pressure; there may be trophic changes, with anæsthesia, paralysis or atrophy.

A localized neuritis or neuralgia of one or more of the nerves of the abdominal wall might be characterized by pain, varying in intensity of boring or stabbing character along the course of the nerve and its distribution, with local tenderness and pain on pressure or motion. Elevation of temperature is rare, and constitutional symptoms slight. There may be anæsthesia, tactile sensation lessened though pain sense increased; paræsthesia with numbness, tingling or formication; atrophy or paralysis, with absence, exaggeration or diminution, of reflexes.

Such disturbances, if they exist in the nerves of the abdominal wall and there is reason to believe that they do, have been given but little consideration, and demand study, because they have undoubtedly led to erroneous diagnosis. Such a group of symptoms with a crop of vesicles is classic in herpes zoster. Head and Campbell conclude that herpes zoster is a specific infective disease in which the virus has an affinity for the nervous system, particularly the ganglia, and considers the disease as an acute posterior poliomyelitis, in contradistinction to acute *anterior* poliomyelitis. Rosenow concludes that this disease is due to a streptococcus having elective affinity for the ganglia and posterior roots.

Herpes zoster of the face and upper intercostals is recognized, and comparatively frequent; but, of the lower intercostals and the first lumbar, if as frequent, is but rarely recognized. The location of the pain and symptoms often lead to a diagnosis of intra-abdominal disease and the hot applications which are frequently applied may cause one to misinterpret the presence of vesicles. Such cases have undoubtedly been operated upon for acute appendicitis. The occurrence of "zoster" of the viscera may no longer be questioned, as such cases are cited in the literature, and the knowledge of such a possibility adds greatly to the difficulties and uncertainties of proper interpretation of the significance of acute abdominal pain.

A local neuritis near the abdominal wall, which, if imitated in the nerves of the right iliac fossa, would cause great confusion is the "meralgia paræsthetica" which is well recognized, and a definite clinical entity. It was described first, by Bernhardt in 1895. In 1900 Musser and Sailer collected 99 cases; and W. J. Rutherfurd reports a dozen cases in the last ten years. The symptoms are caused by a mononeuritis of the external cutaneous nerve of the thigh. (A branch of the second and third lumbar nerves.) There is a local paræsthesia of which the cause is unknown and the treatment unsatisfactory.

Other forms of neuralgia or neuritis which lead one to admit the possibility of a local right-side abdominal painful affection of the nerve are: occipitocervical neuralgia with induration and tender spots. If such areas of induration occurred in the abdominal wall near McBurney's spot erroneus conclusions might be drawn.

Pain such as that of tic douloureux, or intercostal neuralgia if occurring in the distribution of certain abdominal nerves might lead to unnecessary laparotomy. Migraine, sciatica, or lumbar neuralgia, coccodynia, pododynia and other similar affections, if appearing in different locations, might give rise to confusion.

Myositis and myalgia. The fact that localized pain, tenderness and rigidity may be due to pathological conditions within the substance of the abdominal wall seems to

have been consistently overlooked. A myositis in a certain location in the abdominal wall, if unrecognized, might readily be confused with intra-abdominal lesions.

The myalgias, rather loosely defined as painful affections of the voluntary muscle, fascia or periosteum to which they are attached (many authorities claim it to be a neuralgia of the sensory nerves of the muscle) are recognized in certain anatomical locations as lumbago, torticollis, pleurodynia.

Pain is the prominent symptom. The constitutional symptoms are mild, there is no fever and no leucocytosis. An abdominal type of this condition is admitted but it has not been given due attention, and if unrecognized would lead to confusion and error.

The headaches that are accompanied by areas of "induration" usually at the origin or insertion of muscles in the scalp and neck, might well be studied more carefully, and the occurrence of similar phenomena in the abdominal wall might clear up some of the uncertain cases of abdominal pain.

Lead colic. The colic of lead poisoning has frequently led to unnecessary laparotomy because of its very close simulation of intra-abdominal disease. The abdominal pain is general and associated with marked muscular rigidity, noteworthy in being relieved by pressure. Vomiting and constipation are present, the pulse is slow and of high tension with an absence of elevation of temperature. The blood count shows anæmia with stippled red cells and usually no leucocytosis.

Characteristic Burton's lead line, unfortunately is present in only half of the cases, but if discovered the diagnosis is confirmed. A false lead line may be found on the gums of any person working in dirty metallic dusty surroundings. This may be removed by cleaning the mouth and teeth. The true lead line is not *on* the gum, but is *in* the gum, and in its incipiency is not a line, but a series of dots, the result of chemical changes between the lead and sulphur of decomposing particles of food, and will not be removed by cleaning. It is best seen with the aid of a magnifying glass.

In securing the history, it is well to remember that plumbism may occur in occupations other than that given as painter.

Tabes. Nuzum has made a most important contribution to the literature of tabes, in which he quotes from the classic description of this condition by Charcot as follows:

"But of all the visceral symptoms which may display themselves from the period of lightning pains, one which is at once the most remarkable and the least known, if I mistake not, is that which I have proposed to designate by the name of gastric crises. Very often their real signification remaining misunderstood, they are the occasion of grave errors of diagnosis.

"But it is time to tell you in what these gastric crises consist. Suddenly and generally at a period when a paroxysm of shooting pains has seized upon the extremities, the patient complains of pain which, starting from the groins, seems to ascend both sides of the abdomen and to become fixed in the epigastric region. At the same time they complain of pains situated between the shoulders which radiate around the base of the trunk in a lightning-like manner. Then the pulsation of the heart commonly becomes violent and precipitated. Rapidity of the pulse without fever is, in truth, a very common incident. Almost incessant and extremely distressing vomiting is often associated with gastric crises. Food is first ejected, then a mucous, colorless liquid sometimes mixed with bile or tinged with blood. An intense feeling of sickness and vertigo are superadded to the vomiting and cardialgic pains. Many a time I have seen this symptom diverting the attention of the physician and causing him to misapprehend the real nature of the disorder. I also have several times fallen into the snare in other days."

The gastric crises of tabes has, until very lately in the minds of many physicians, been considered a rare, unusual, and late manifestation of cerebrospinal syphilis.

That many cases of gastric crises have been mistaken for acute abdominal lesions has been more or less imperfectly realized, but Nuzum's article entitled, "Needless Surgical Operations from Failure to Recognize Tabes Dorsalis," is of great value in attracting attention to the frequency of the slipshod or careless methods taken to arrive at a diagno-

sis. Nuzum collected and analyzed the records of 1000 cases of tabes treated in Cook County Hospital during the four years, 1910–1915. In these 1000 cases, 97 needless operations had been performed upon 87 patients.

"In estimating the number of operations, only those have been included in which the patients were told by the surgeon that nothing wrong was found, and in which the old symptoms returned following the operation. Cases have been excluded when scars of previous operations were found in the epigastrium, kidney or appendix region, with no record of what was found or done at the operation, recorded on the history sheets, or when this could not be learned from the surgeon.

The surgeon's diagnosis in these cases was as follows:

Gastric ulcer	19
Gall-stones or cholecystitis	19
Appendicitis	18
Salpingitis	13
Exploratory laparotomy	9
Renal calculi	7
Postoperative adhesions	7
Tumor of cauda equina	1
Sciatica (nerve stretching)	1
Meningocele	1
Ectopic gestation	1
Peritonitis	1
Total number of operations	97

The occurrence of real bona fide abdominal pathology in conjunction with tabes must not be lost sight of. Nuzum recognizes this fact and excludes such cases, and reports a case of perforation of a duodenal ulcer in a tabetic that was discovered, at autopsy, by LeCount.

Just because a person has tabes it in no way eliminates the possibility of an acute abdominal emergency, or any other type of an emergency, and it is just such possibilities that make the personal equation of the diagnostician of so much importance. A study of the cerebrospinal fluid is of value, as an increase in the cells is quite a constant finding, even in the early stages. A positive Wassermann is of great value but is not conclusive, as there is a percentage of error variously estimated from 1 per cent up. False positives may occur in cancer, tuberculosis, scarlet fever and Hodgkin's disease; 25 per cent to 30 per cent of luetics are negative in tertiary stages, as also are the so-called "parasyphilitics."

A provocative dose of antiluetic treatment will reduce this percentage of error materially. In all doubtful cases, both the blood and the spinal fluid should be examined.

Cabot summarizes the matter by saying: "What we are learning in the last few years, since lumbar puncture and Wassermann reactions in the blood and spinal fluid have become matters of routine in doubtful gastric cases, is that any type of stomach trouble, acute or chronic, mild or severe, sharply painful, or merely distressing, may be due to cerebrospinal syphilis. Until within the last few years, one was on the lookout, if he were conscientious, for so-called gastric cases in tabes. What we have learned lately is: (a) That we must suspect the possibility of tabes even when the pupils are normal and must investigate this possibility by means of spinal puncture; (b) that any sort of gastric abdominal pain or distress may be due to tabes."

I shall merely present Nuzum's conclusions, which represent the concensus of opinion on the subject at this time, and urge that this article be not only read, but carefully studied, by every one who presumes to perform laparotomy:

It is believed that with a careful examination to exclude tabes, in the future more tabetics will be spared useless surgical operations, and more acute abdominal symptoms will be proved of spinal origin.

1. Of 1,000 tabetics, 8.7 per cent have been subjected to laparotomy under mistaken diagnosis one or more times.

2. The "crisis" of tabes has largely influenced the surgeon in his decision to operate. This statement is supported by the fact that 65 per cent of the 87 patients operated on presented visceral crisis. In 17 per cent of these the "crisis" was the initial symptom of their disease.

3. Mistaken diagnosis and resulting operations occur chiefly through failure to examine the nervous system.

4. Gastric ulcer, gall-bladder disease, and appendicitis are the diagnoses most frequently made.

5. Tabetics subjected to several successive laparotomies have, as a rule, been operated on by as many different surgeons.

6. A history of paroxysmal attacks of vomiting, rheumatism, paræsthesias, bladder disturbances, or fractures without physical violence, should excite interest to exclude tabes dorsalis.

7. The cytodiagnosis of the cerebrospinal fluid, together with the Wassermann reaction with the spinal fluid, are of inestimable value in doubtful cases.

Hysteria, with its protean manifestations may, of course, be mistaken for intra-abdominal lesions. Clavus hystericus, so well known, if transferred to the right iliac fossa would many times be operated upon with a diagnosis of appendicitis. Still there is no reason why the same severe pain may not occur in the abdomen, instead of the head.

Such tender spots do occur in the hysterogenetic points, viz., the breast, trunk, spine and upper and lower abdomen, and it is the type of painful spot in the lower abdomen that has been responsible for the ovariotomy furor, and now the appendectomy craze.

Tympanites or phantom tumor may likewise confuse the issue.

Careful history taking and complete examination with the discovery of anæsthetic areas, or superficial tenderness greater than that elicited by deep pressure with an absence of temperature or leucocytosis will usually prevent error.

INTRA PERITONEAL LESIONS

Intraperitoneal lesions that may simulate surgical conditions may include: cardiospasm, cirrhosis of liver, acute dilatation of stomach, acute gastritis, acute enteritis, ptomaine poisoning, typhoid fever, angioneurotic œdema, gastroptosis, mucous colitis, chronic intestinal stasis, salpingitis, dysmenorrhœa, pregnancy and others.

Cardiospasm. It is but a comparatively few years since abdominal operations were performed for various conditions in which undetected and unsuspected cardiospasm was the real cause of the symptoms. Smithies reports 34 cases, in but 5 of which had the possibility of cardiospasm been considered. X-ray, careful history, and examination will prevent such error.

Cirrhosis of liver. Biliary or hypertrophic cirrhosis (Hanot) is characterized by jaundice, an enlarged liver, attacks of pain in the region of liver, that may be severe and associated with nausea and vomiting, possibly with slight fever, and leucocytosis. The negative features are absence of ascites and dilatation of the blood-vessels.

Because of the gastric attacks, jaundice and enlargement in the region of the gallbladder, this condition is not infrequently confused with cholecystitis.

Portal or atrophic cirrhosis (Laennec) is characterized by small contracted liver, ascites, and portal obstruction manifested by the caput medusæ, hæmatemesis or melæna.

According to Rolleston, and confirmed by Cabot, acute symptomless hæmatemesis occurs in 20 per cent of gastric and duodenal ulcer and in 20 per cent of cirrhosis of liver.

"Dyspepsia" is a common symptom as is the "hepatic facies," viz., eyes sunken, conjunctiva watery, nose and cheeks showing distended vessels and the complexion muddy and ichteroid. Cerebral toxic symptoms may develop any time and are usually mistaken for uræmia. The ascites may lead to a diagnosis of tuberculosis of the peritoneum or malignancy. The disease is not rare.

The Talma-Morrison omentopexy has not been accepted as superior to tapping, and the establishment of Eck's fistula, i.e., portocaval anastomosis has met with little favor since its first performance on man, by Widal, in 1903.

Mayo states that his experience with splenectomy in cases of splenic anæmia has been such as to encourage him to splenectomize in suitable cases of portal cirrhosis, especially when the spleen is enlarged.

Acute dilatation of the stomach may be mistaken for peritonitis or ileus. Laparotomy is rarely indicated, as gastric lavage will not only make the diagnosis, but will serve as a very effectual therapeutic measure.

"Acute indigestion" is a term used rather loosely to indicate a condition in which the usual gastric symptoms present, but this name can, consistently, be applied only to those in which the symptoms end by the emptying of the stomach.

In acute gastritis there may be temperature; the usual absence of a leucocytosis will aid in differentiation. The abdominal pain may be intense, and the attacks may be confused with cholecystitis or appendicitis. This differentiation may be at times extremely difficult.

Acute enteritis may be accompanied by abdominal pain; but a temperature and leucocytosis is usually absent. The pain and tenderness are not localized.

In ptomaine poisoning, there is no fever and no leucocytosis; but there is abdominal pain, cold sweats, vomiting, continued diarrhœa and subnormal temperature.

As a general proposition, with infection, there is fever; but with poisoning there is no fever. Many "gastritis," "enteritis," and "ptomaine poisoning" cases are gastric ulcer, gall-bladder or appendiceal infections.

An acute abdominal pain in the course of typhoid fever must always be given serious consideration. A coincident appendicitis is not rare. Perforation varies greatly in frequency but it has been estimated to be the cause of death in about 12 per cent of the fatalities. Perforation occurs in about 3 per cent of all cases; 80 per cent in the lower ileum and usually during the second and third week. Characteristic of perforation, we find acute abdominal pain, rise of blood pressure, increase of leucocytosis. This may be a comparative increase and still be below normal; therefore the necessity of a close observation of the blood during the course of the disease.

With these symptoms exploration is indicated. They may be found to be due to conditions not remediable by operation, but to await more conclusive signs of peritonitis is to await a time at which treatment is usually unavailing.

In the literature we find many cases in which exploratory laparotomy was not followed by disastrous consequences. The diagnosis is most difficult because, to quote Remsen: "The unraveling of such a complication involves some of the prettiest diagnostic problems in acute abdominal surgery, for it involves, not merely the diagnosis of an acute abdominal condition *per se*, but rather its diagnosis through the veil of signs and symptoms pertaining to another existent acute abdominal condition, if we may class typhoid fever as such."

Typhoid fever must always be excluded in doubtful cases. Of great value is a history of temperature previous to the attack of pain. The enlarged pericæcal glands may simulate an appendiceal abscess and may give rise to pain and tenderness.

The leucopenia, the Widal, and the other typical signs of typhoid or paratyphoid, should be looked for.

Angioneurotic œdema. The appearance of this disease in the skin has been well known since Quincke's description of it in 1882, at which time it was known by his name.

It is only recently that attention has been drawn to the fact that visceral occurrence of exudative phenomena similar to those observed upon the visible surfaces of the body, such as urticaria, erythema, purpura, all belong to the angioneurotic group, an angioneurosis, that may give rise to abdominal pain which may cause even experienced observers to open the abdomen in the belief that some acute surgical pathology exists.

This condition may be due to chemical or toxic irritation, to faulty metabolism or to anaphylaxis. William Osler has given this subject considerable attention and in a report of 29 cases cites Henoch's purpura in which intense agonizing attacks of colic have occurred with no cutaneous manifestations. The decrease in red cells and hæmoglobin in these cases is most striking, though there may be elevation of temperature and increase in leucocytosis. Because of the variability of the skin lesions, and of their absence in some attacks, patients rarely associate the skin conditions and the abdominal symptoms. In children particularly, careful history taking should attempt to bring out previous attacks or lesions of the skin, inflammation of joints, or abdominal colic or crises. In adults, one is often struck by what may be called a neurotic tendency of the patient and one will note the indefiniteness of the nature of the abdominal pain, which does not conform to the type found in the usual surgical lesions.

There is one type which lasts a few hours. This may be mistaken for gall-stone colic, or, with hæmatemesis it may be confused with gastric or duodenal ulcer. Another type of longer duration, is frequently associated with a swelling in the right iliac fossa, and may suggest appendiceal abscess.

Such cases have been frequently operated

upon, and a brawny induration of the entire cæcum, appendix, and lower ileum is encountered. The appendix does not show sufficient change to be the primary cause of the condition. Harrington cites 1 case of this type, Osler 3, Riggs 4, and Mayo 3.

In cases seen for the first time, in which there is large tumefaction of recent duration in the cæcal region, severe pain without local peritonitis and with the patient in good general condition, out of all porportion to the suspected lesion, a history of previous swelling should be carefully sought, and, if found, watchful waiting is good surgery.

Crispin, in an article entitled "Visceral Crises in Angioneurotic Œdema" considers this subject *in extenso* and cites cases from the Mayo Clinic. His conclusions are as follows:

"When a history of severe abdominal pain is given which does not conform to true surgical types, careful inquiry should be made as to the presence at any time of urticarias, erythemas, purpuras, and swellings of angioneurotic œdema types."

A history of recurrent severe abdominal pains with constancy in the nature and duration of the attacks with skin manifestations of any of the exudative erythemic forms, with or without noticeable association with the abdominal pains, should excite suspicion as to the presence of crises of angioneurotic type.

A diagnosis of visceral crises of angioneurotic type should not be made until careful examination has excluded or made independent surgical causes. In this, roentgenologic examination of the gastro-intestinal tract is valuable negative evidence. Syphilis and tuberculosis should be excluded.

The constancy in the recurring attacks of the pain, not conforming to surgical types, in patients who have had skin manifestations of the exudative erythema group and whose general condition does not account for the suffering they have had to bear, will warrant a diagnosis of visceral angioneurotic œdema.

Repeated, or even single attacks, of intestinal colic with tumefaction in which the patient's general condition is too good for the extent and severity of the trouble, and in which history of the swellings can be obtained, may be of this type. To wait is good surgery. The rapid return to health is strongly suggestive of visceral angioneurosis.

Having determined the medical nature of these angioneurotic visceral crises, we should endeavor to work out the sources of toxæmia. There may be foci of pus in the upper respiratory tract and sinuses, bacterial absorption, idiosyncrasies to heat, cold, chemicals, parasites, carbobydrates or proteins that are the causes for anaphylaxis.

Removing the cause for anaphylaxis, whether it be idiosyncrasy in one patient for ice cream, some constituent, such as cold bananas in another, alcohol in a third or any anaphylactic base or source of exogenous or endogenous irritation or poison, may give the patient relief that the advised surgery would not have given him.

Appert, from France, likewise calls attention to this pseudoperitoneal syndrome due to urticaria-purpura or polymorphous erythema.

Since the work of Richert, and others, Appert considers urticaria to be an anaphylactic phenomenon, and that the cutaneous troubles are only the outward and visible manifestations of sudden changes in the blood called by Widal a "hæmoclassic crisis."

Visceroptosis. The important phase of surgery in which visceroptosis has caused symptoms leading to unnecessary abdominal operations has been handled in a masterly fashion by Albert J. Walton. Thirteen cases were operated upon under the impression that the condition was an acute abdominal lesion — appendicitis, the remainder of the total 67 were mistaken for chronic abdominal disease — chronic appendicitis, gall-bladder disease or gastric ulcer or cancer. Differing from appendicitis one finds a previous history of repeated attacks of a mild character and short duration. There may be a slight increase in temperature and slight rigidity. Walton well says, "If in doubt always better to diagnose appendicitis and operate."

Archibald MacLaren in a consideration of "Chronic Appendicitis and Visceroptosis," says: "The neurasthenic or visceroptosis case sometimes simulates the *acute* but usually is mistaken for *chronic* appendicitis."

Constipation-stasis. This subject, despite its enormous literature, is still unsettled and obscure. It is more intimately connected with the chronic than with the acute abdomen, but as these cases are being operated upon and are being advised to undergo operations for acute abdominal conditions, it must be mentioned at this time.

This error in diagnosis also occurs in other countries; for example, in London, as shown by the report of Walton; in Germany, by that of Wilms; in Amsterdam, by that of Laewen, in Norway, by that of Widore. The latter reports 23 cases of intestinal stasis occurring in 1912, in 16 of which the family doctor had sent the patient to the hospital urging immediate operation, but in all the trouble was merely intestinal stasis.

In view of the above citations, from England, Holland, Germany, Norway, and I suppose a search would reveal similar reports from other countries, it would seem that some reason for this diagnostic error must be looked for, that is general, geographically, and that may be effective in all communities regardless of the type of education or the traditions, and customs of the profession.

And such a cause will be found, it seems, in nothing more obscure than sheer laziness, in which acceptable diagnoses are made without sufficient data, the so-called "snap shot" diagnosis, which it seems is quite universal; an international and not a national failing.

Mucous colitis. Colica mucosa of Nothnagel is such a large and little understood subject that I shall not attempt to present a consideration of the topic but merely call to your attention the fact that this disease is quite common, though frequently unrecognized, that it is characterized by attacks of very severe abdominal pain with great tenderness that has many times been mistaken for intra-abdominal inflammation. The condition is associated with neurasthenia. The relation of one to the other like that of the chic to the egg, is not as yet determined.

In mucous colitis there are localized spots of cutaneous hyperæsthesia.

"The areas of cutaneous tenderness pointed out by Head as corresponding to disease of internal organs have been verified in most particulars by subsequent observers. Those which correspond to the intestines as far down as the upper part of the rectum, are the ninth, tenth, eleventh, and twelfth dorsal segments. Their respective positions are: left costal margin above the center and one inch from the end of the rib; just to the right of the umbilicus; just above the left anterior superior spine; and just above the middle of the right Poupart's ligament."

The presence of one of these spots last mentioned has been sufficient many times for the removal of an unoffending appendix. There is likewise a tenderness with rigidity on palpation along the course of the colon. There is in conjunction, a gastroptosis, enteroptosis, nephroptosis, a so-called "habitus enteropticus." Constipation is usual; though diarrhrœa may alternate with constipation. At times, usually before evacuation of the bowel, there is a colic which may be very severe. The passage of thick glairy mucus in variable amounts is characteristic. This mucus may be rolled into worm-like masses that may be looked upon, by the patient, as worms.

This condition is a neurosis and not an inflammation; consequently there is usually an absence of leucocytosis and temperature.

Van Norden and Nothnagel have described the condition, and Henschell and Abraham have published a large monograph, Spitzig of Cleveland has considered the subject and Capperoani in a recent article dwells particularly upon the pseudo-appendicitis attacks that may occur in this condition.

This is a very obscure question and greatly in need of elucidation. Therefore it will not be considered further than merely to mention the fact that it is a frequent source of error in hasty examination and hurried diagnoses.

Salpingitis may be confused with appendicitis but a vaginal examination, with careful history, will usually clear up the diagnosis.

The question of the advisability of delaying operative interferences in acute pelvic infections until the acute inflammation has subsided, has, it would seem, been definitely settled by the observations of Simpson.

In but very rare instances is surgery indicated, danger to life is slight, the danger of

non-operative treatment is largely one of continued morbidity and recurrent infections. A coincident acute appendicitis should, of course, be treated by accepted radical measures. Simple dysmenorrhœa may be mistaken for acute abdominal inflammation. The history and close observation will prevent such confusion.

During the course of pregnancy there is sometimes a tendency to complain of pain and tenderness; sometimes a severe colic, in the right iliac fossa, which has been responsible for operation with a diagnosis of appendicitis, in which the findings did not coincide with the subjective symptoms.

An explanation has been offered by DeLee as follows: "This pain is almost always in some relation to McBurney's point, and is due to the dextrotorsion of the uterus, throwing the right tube and ovary forward, with a resultant compression of these delicate organs between the utero-abdominal walls."

But, whether or not this is the proper explanation, the clinical fact is well worth remembering. The frequency of appendicitis in pregnancy has been variously estimated, but I shall merely quote from two prominent obstetricians in a recent discussion. R. W. Holmes says, "I wish to take issue with Dr. Beck in his statement that appendicitis in pregnancy is very common. It naturally falls out that the findings of the general surgeon on this question will give a higher proportion than would be the case of the obstetrician. I have repeatedly had women complaining of right-sided pain, *but that is not appendicitis*, although I am sure many a pregnant woman has had her appendix removed hurriedly on account of such pain."

Dr. DeLee says: "I am quite confident that many a so-called appendicitis in pregnancy is merely a mild toxæmia of pregnancy: the physiologic leucocytosis of pregnancy, coupled with nausea. Epigastric, or perhaps right-sided pain, misleads one into operating erroneously for an appendicitis which does not exist."

CONCLUSIONS

These remarks have been rather brief and sketchy; in fact a mere running commentary upon a certain phase of surgery that is becoming more and more important. Other confusing conditions should have, in all probability, been included; differential points may not have been sufficiently and properly emphasized but the effort has been to direct attention to the fact that these various conditions may simulate intra-abdominal lesions; some of which may have slipped your mind; and that a diagnosis to be worthy of the name, must be based upon a careful history of the case, complete observation, and accurate interpretation of the data so acquired.

As showing the importance of careful history taking, Behlow says: "From a careful history one can make a positive diagnosis of the primary or major conditions in 53 per cent of the cases."

The same care in taking a history will make possible a positive diagnosis of the secondary condition in 41 per cent of the cases.

If the above possibilities are kept in mind and each case given careful study, our unsatisfactory results will decrease. This fact has been well recognized for centuries and has been consistently neglected, as has been shown by DaCosta in an article on "Principles of Surgical Diagnosis," in which he quotes Benjamin Franklin: "Want of care does more damage than want of knowledge"; and Sir William Gull: "We make more mistakes from not looking than from not knowing."

The coincidence of curable surgical lesions in individuals afflicted with non-surgical and incurable disease must be recognized, and the fact anticipated, that the cure of a definite surgical disease in a chronic neurasthenic does not necessarily mean a cure of the neurosis. Or in the trite words of Deaver: "The abdomen will be found to be a veritable Pandora's box of troubles, which do not, however, always fly away when the box is opened."

LAPAROPLASTY BY A NEW METHOD

By WELLER VAN HOOK, A.B., M.D., Chicago

THERE is a vast number of people whose intra-abdominal organs are improperly housed on account of defects of the walls bounding and maintaining the cavity of the abdomen. These people await rational and generally applicable methods of reconstruction of the greatest cavity of the body.

The abdomen is a walled space in which are housed various highly important structures. The spinal column, supporting the head, neck and trunk, passes through the posterior wall of the abdomen and forms a part of that wall. The muscles of the abdominal walls have the duty of maintaining the tension of those walls, but this is only one of their important functions, since they steady the spinal column and flex in the various directions the entire trunk. These walls may be encumbered with fat deposits and they may be weakened; stretched; torn; destroyed by wounds, inflammation or neoplasms; pouched or paralyzed. These changes themselves and the lesions of the intra-abdominal structures consequent upon or associated with them make necessary great efforts on the part of surgeons to devise methods of re-fashioning the abdomen so that the form and cubic contents of the *cavum abdominis* may be remodeled, the walls strengthened, the defects made good, the muscles given better lines of action, and the distance diminished between the origin and insertion of certain muscles, while encumbering tissues are removed.

The simplest and most obvious laparoplasty is that of J. Clarence Webster[1] who has operated in a large series of cases of defective abdomens, with and without diastasis of the recti. He removes by incisions parallel to and including the median line from ensiform to pubes, a long strip of skin and subcutaneous fat; then, opening the sheaths of the recti muscles, he sutures together the posterior plates of the sheaths and, separately, the anterior plates. He has had excellent results, the abdomen becoming narrower, burdened with less fat and far more under the patient's control.

Depage in 1893 proposed and carried out a laparectomy and a laparoplasty. By the first term is meant the removal of redundant tissues from the abdominal wall. This is especially desirable when the patient is burdened with an enormous fat deposit. Far more important is his laparoplasty. His operation is as follows:

An incision is made across the abdomen from the tip of the eleventh rib of one side to the tip of the eleventh rib of the other side. From the extremities of this incision two incisions run obliquely to points at the level of the umbilicus and 5 centimeters from the median line. From the two lower ends of these incisions two outwardly curved incisions are carried downward to a point

[1] Textbook of Gynecology.

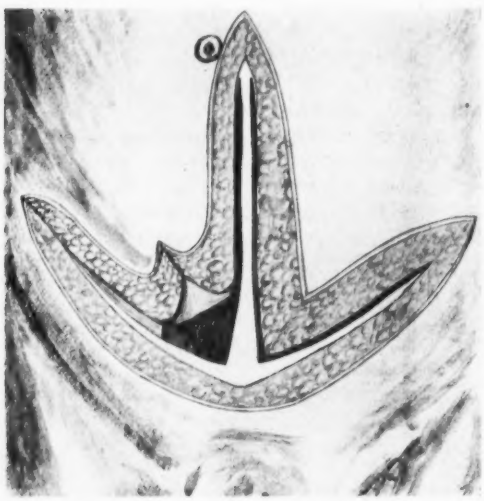

Fig. 1. Drawing showing the incision and the raising of the flap on the right side.

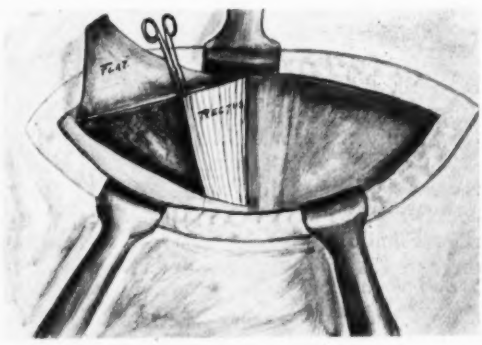

Fig. 2. Raising the flap for the right side, cutting through the right lateral wall of the rectus sheath.

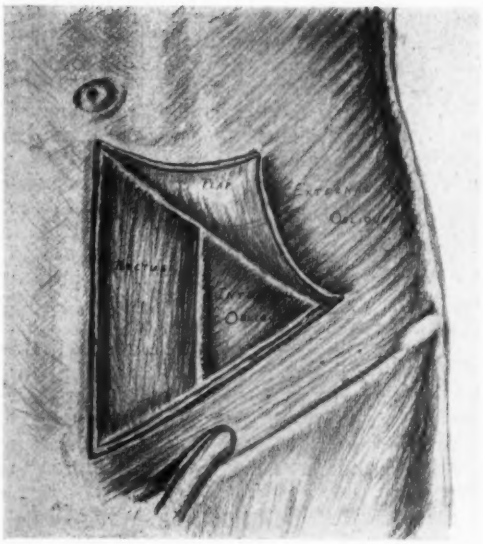

Fig. 3. The relation of the raised flap to the three muscles concerned.

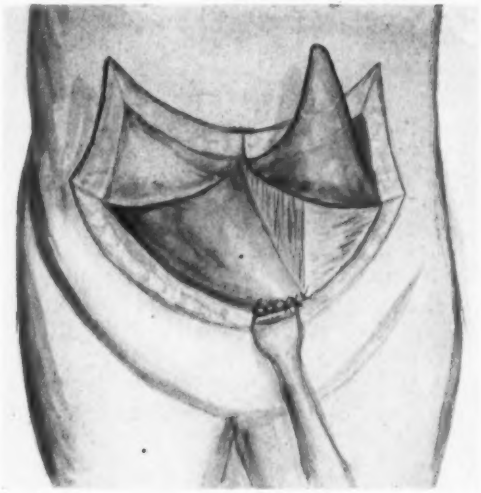

Fig. 4. The two abdominal wall flaps have been formed. The right hand flap has been carried across the median line and sutured nearer the level of the pubic bone. The flap for the left side is raised and beneath it are seen the bodies of the rectus and internal oblique muscles.

above the pubes. Then follows excision of the skin and connective tissue of the included area, the median line and the peritoneum, back to the edges of the recti muscles. Three layers of sutures close the abdominal wall, leaving a T-shaped scar. Depage's operation has been frequently performed by others as well as by himself with reports of satisfaction.

Coffey's operation[1] consists in making an incision through the external oblique muscle parallel to Poupart's ligament, lifting up that muscle from its bed and carrying it over the outer part of the muscle to a lower level, where it is stitched down. This very valuable operation is open to some objections, which are the facts that, for lesions involving the entire lower abdomen, the retrenchment is local and may be inadequate, and that the new abdominal muscle stress is laid upon the external oblique muscle alone and that, too, in a direction *perpendicular to the course of its fibers*.

The writer's laparoplasty for relaxed, pouching, or pendulous abdomens is as follows:

A median laparotomy wound is made in the lower abdomen and if necessary this may be extended well above the umbilicus, which is best excised. A median hernia, if present, is managed by severing adhesions, replacing organs and closing the retrenched peritoneum. The deeper wound is well protected by hot compresses. Laparoplasty is then carried out. From a point in the median line about one or two inches above the *symphysis pubis* incisions to the right and left are made starting at right angles to the median line but, at the outer edge of the recti, turning upward and outward in the direction of the fibers of the external oblique muscle and extending to a distance of six or more inches on each side, splitting that muscle.

Next, each of the triangular flaps thus produced, of which the apices point downward, is lifted carefully by separating the external oblique muscles (bearing their aponeuroses) up to the recti from the underlying internal oblique muscles. Then the anterior plates of the rectus sheaths are dissected up from the muscle-bodies. These powerful connective-tissue membranes lifted off from the bodies of the muscles, leave the recti bodies in their normal beds. The raised rectus sheath-flaps are now in continuity with the bodies and aponeuroses of the external oblique muscles. The effect of this work is to provide us with two triangular flaps pointing toward the pubes and consisting of parts of the sheaths of the recti and a large part of the external oblique muscles.

The next step is the crossing and reattachment

[1] Surg., Gynec. & Obst., 1912, xv, 365.

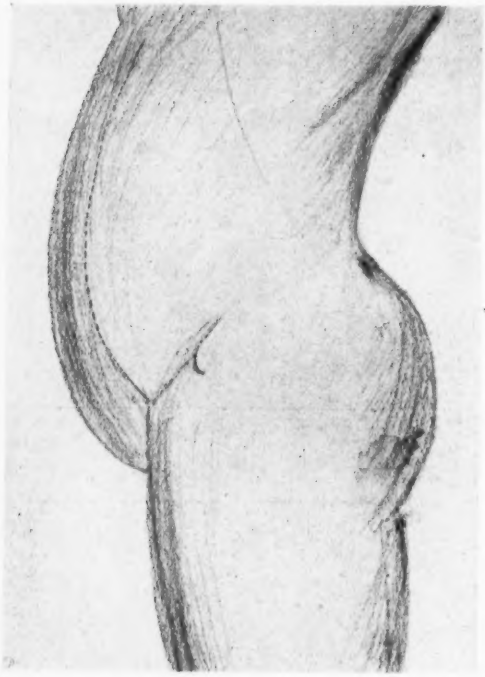

Fig. 5. Showing the sternopubic line of the pendulous abdomen in the erect posture.

of these flaps at points much lower than those to which they extended previously. To effect this one puts the patient in the Trendelenburg posture, then flexes the knees and moderately flexes the thighs upon the abdomen, providing under the legs a suitable support. The effect of these maneuvers is to diminish the pressure within the lower abdomen, thereby relaxing the muscles of the abdominal wall and also, by anteriorly flexing the spine, to lessen the distance between the ensiform cartilage and the pubic bone.

We can now draw the left flap downward to the right of the pubic bone across the median line until it is almost taut. It is carefully sutured to the apnoeurosis of the right external oblique, to Poupart's ligament and to the anterior sheath of the right rectus muscle at a level much nearer the pubes than that from which it was raised. The flap of the right side is similarly carried downward and to the left over the left rectus muscle and over the first flap and sutured in position.

The skin and subcutaneous fat are extensively retrenched and the T-shaped skin incision closed.

It will be observed that in this laparoplasty the T-shaped incision is inverted; in Depage's operation the T is upright.

This operation has been performed by the writer in two cases of large postoperative hernia in women, with the most gratifying results. The hernias were cured, the abdominal walls were given what physical trainers call a tucked-up appearance and the patients felt distinctly the improvement in voluntary control of the lower

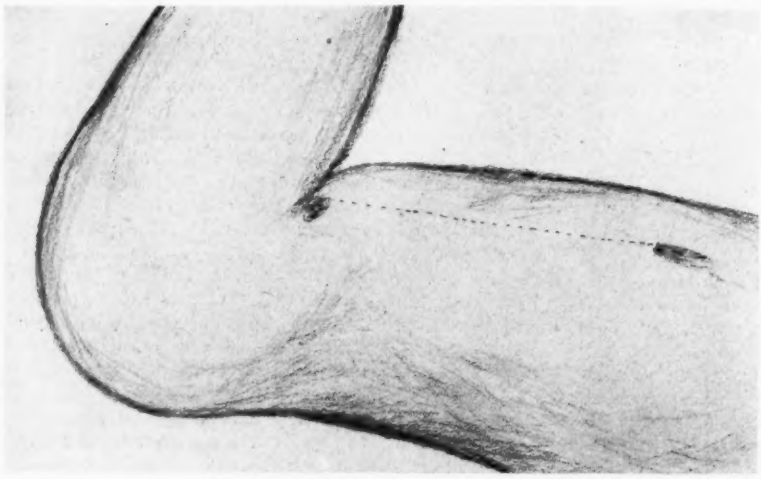

Fig. 6. The sternopubic line in the Trendelenburg position.

part of the trunk, while the viscera were obviously held better in position.

The nerve- and blood-supply of the tissues involved are not compromised by the incision recommended and careful attention to strictest asepsis should yield primary healing.

The operation is recommended for plastic purposes (1) where, as in military practice, or in case of sloughing inflammations or of neoplasms requiring excision, loss of tissue has occurred; (2) where hernias through the anteromedian structures are too extensive for simple plastics; and (3) where relaxation due to fat deposits, to lordosis, to paresis etc., has resulted in pendulous abdomens causing weakness, inconvenience or interference with the function of the viscera.

ACUTE APPENDICITIS COMPLICATING EPIDEMIC INFLUENZA

With Report of Eight Cases[1]

By MOSES BEHREND, M.D., Philadelphia

THE recent epidemic of influenza accompanied often with its most lethal complication, pneumonia, has furnished many occasions for the physician to make a differential diagnosis of a chest or abdominal condition. It is a well known fact that the referred pain of a right-sided pneumonia often simulates the pain of an acute appendicitis. Many mistakes have been made in the past and many no doubt will continue to be made on account of the intimate relation of the nerve distribution covering the lower part of chest and abdomen. Numerous cases of pneumonia have been operated on in the past for pneumonia, and vice versa cases of appendicitis have been treated for pneumonia with disastrous results in the majority of cases. In patients in whom the two cannot be separated it is better to operate with the aid of nitrous oxide gas and oxygen anæsthesia. In case a mistake has been made the course of the pneumonia in my experience has not been altered. All the cases pursued their natural course and ended in resolution.

Close inspection without the aid of any other physical signs will often make the diagnosis. Other signs are not of much value because early in pneumonia practically nothing is elicited on auscultation and percussion. The one sign which more than any other differentiates pneumonia from appendicitis is rapid breathing and playing of the alæ of the nose. These signs are absent in acute appendicitis.

During and after the epidemic of 1888 and later also in the milder epidemics, many cases of appendicitis were reported. It has been a constant observation of physicians that appendicitis occurs in increased numbers after epidemics of influenza. The period of time between cause and effect varies. Many cases have been reported during the height of an epidemic but most of the cases of appendicitis occur some time after the patient is well. In 1888 several cases with pain in the right iliac region were diagnosed typhlitis. These cases were probably appendicitis.

Leichtenstern believes we are not dealing with acute appendicitis but rather with a typhlitis; that exceptional cases of true appendicitis may occur especially when the Pfeiffer bacillus has been isolated; that coincidental appendicitis, when it does occur, simply accompanies an attack of influenza. In only one of the eight cases observed by me was there any history of several previous attacks of appendicitis. Nor can I subscribe to the theory of typhlitis advanced by this author. Such cases were primarily appendicitis, the inflammation spreading to the cæcum by continuity.

About ten years after the epidemic of 1888 when appendicitis was better understood as a distinct entity several cases were reported.

Merklin reported three cases which were not operated upon. One of the cases however discharged the abscess per rectum.

In 1901 Charpentier observed 5 cases of appendicitis in an epidemic of grip that

[1] Read before the Philadelphia County Medical Society, October 23, 1918.

affected a regiment of soldiers in France in 1899. These cases were not operated upon and recovered. In only one case was there a previous history of appendicitis.

Franke believes there is a causal relation between influenza and appendicitis. He states that appendicitis has become very common since the great epidemic of influenza in 1888. Some of his cases occurred in two to three weeks, others in as many months after influenza. Again he has seen cases simultaneously in the same family, a condition observed by other physicians. He also believes that in influenza, appendicitis is often simulated—a pseudo-appendicitis.

Jolaguier has noted cases of appendicitis in the course of influenza as has also Faisant who goes so far as to state that grip is the main cause of appendicitis. He bases his opinion on the fact that there has been a large increase in the number of cases of appendicitis since the last great epidemic, and that there is a recrudescence of appendicitis after each annual epidemic of influenza.

Weitlaner found in his cases now and then Pfeiffer bacillus influenzas but the pneumococcus influenzas predominated in the locality under his observation in 1909. Curschman quoted by Weitlaner confirms this statement. Weitlaner believes that a pneumococcus influenza associated with a pneumococcus angina forms the basis of a series of cases of appendicitis. He states that the pneumococcus had been found in the appendix and peritoneum by a series of investigators. He quotes especially Jensen who found pneumococci in the circulating blood in ten cases of appendicitis. Jensen himself found the pneumococcus in appendicitis in 20 cases, never, however, in pure culture as had been found by Krogius in one case. Weitlaner is a firm believer in the infection of the appendix by the hæmatogenous route, at least so far as the pneumococcus influenza is concerned.

The occurrence of appendicitis in influenza is not mentioned at all by Althous in his fine treatise on the subject of influenza.

The writer has seen in all 8 cases of acute appendicitis complicating influenza. Seven of these were seen in consultation with other physicians. Three were operated on and found to be pus cases. Not any of these gave a previous history of appendicitis. In one the appendix ruptured while in the other two pus was contained in the appendix. All the cases recovered. The other five cases were not operated upon because it was feared that the prevalence of râles in the lungs would eventually result in pneumonia. This may seem contradictory to the statement made earlier in this paper, but the wide diffusion of moist râles in the lungs reminded one more of an extensive œdema than a characteristic pneumonia. On account of the "wet" lung the administration of an anæsthetic was feared.

Of these cases six were adults and two were children. All were taken sick during the height of the epidemic and had been in bed on an average of four days before the symptoms of appendicitis developed. In those not operated on the symptoms gradually subsided.

It will be interesting now to observe whether there will be an appreciable increase in the number of cases of appendicitis following the recent virulent form of epidemic influenza.

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PRIMARY SUTURE OF WAR WOUNDS

By GEORGES GROSS, Nancy, France
Graduate Professor of the Medical University of Nancy; Consulting Surgeon to the Fifth Army

PRIMARY suture of war wounds is certainly one of the burning questions of the day and quite justly so. At the outbreak of the war, the theory of expectant treatment was the accepted rule. Those of us who had the greatest number of consecutive cases to deal with saw almost at once that in many of the wounded, fatal accidents would sometimes occur. The practice of large, open incisions systematically made and followed by rigorous drainage which I was one of the first to advocate[1] was the next step as opposed to the "wait and see" policy. This practice had proved its value, but however excellent it may have been, it certainly had its disadvantages. War wounds which are infected remain so after wide incisions are made, even when they are followed by irrigation with antiseptics, let them be what they may (ether, peroxide of hydrogen, Dakin solution). From our desire to improve the results obtained by disinfection with antiseptics has been evolved mechanical disinfection. At first efforts were made to obtain mechanical disinfection by scrubbing and brushing the wounds; later by *l'epluchage*, or the cutting away of all infected tissue, a procedure which is really better named excision, for it is by wide excision that one must remove all bruised, infected and dead tissue, together with the projectile and all dirty extraneous material. In spite of excellent technique a certain number of wounds widely opened would suppurate for a long time, either from the persistence of the primary infection or from secondary infection. Others equally carefully excised, would clear up so readily and perfectly that one was tempted to believe in the possibilities of primary suture. The results obtained were often favorable, but it is true that there was a certain number of failures, even accidents, which caused many to regard primary suture in most cases as an exceptional method of treatment and in others a dangerous proceedure. As regards myself, I was an enthusiastic advocate of it, since my colleague Loubot showed that, after scrupulous disinfection of the fractured bone surfaces, an open joint could be completely closed, and in nearly every case union by first intention was easily obtained.[2]

The well known treatise by Loubot has certainly had a great deal to do with the triumph of this method. During the summer of 1915, with the army before Verdun, then afterward on the Somme, primary suture began to have numerous advocates. Since June, Houdard and myself[3] used with almost constant success the suturing of cerebrocranial wounds. Wounds of the soft parts, even in the presence of fractures, were also sutured during this period. Grégoire and many surgeons at the front hospitals believed, and rightly, that primary suture would be the coming method.

What is essential in deciding as to whether primary suture should be used in treating war wounds: (1) the time that has elapsed between the receipt of injury and the period of operation; (2) the anatomical possibility of making a complete and perfect removal of all damaged and crushed tissue and of extracting the projectile; (3) clinical experience which would enable the surgeon to decide from the general aspect of the wound whether reunion would be successful.

When for one reason or another one has not dared to do a primary suture, he could, at the end of 15 or 20 days, when the wounded man has become afebrile and the wound has a clean look, perform secondary suture. Secondary suture which can be carried out very well, as I have demonstrated, on a wound treated with aseptic dressings, is generally followed by a course of treatment with the Dakin solution according to Carrel's tech-

[1] Bull. et mém. Soc. de Chir., 1915, Jan. 27.

[2] Loubot. Bull. et mém. Soc. de chir., 1916, June 28; and G. Gross, ibid., 1916, Oct. 18.

[3] G. Gross and Houdard. Bull. et. mém. Soc. de chir., 1917, May 30, and Dec. 5.

nique. In order to determine when it is possible to perform secondary suture, Carrel and after him Depage, made bacterial counts of the wound discharge. During treatment of the wound it was found that the number of bacteria gradually decreased and finally assumed negligible proportions. Only then was secondary suture done. This technique marks the appearance of bacteriological control in the treatment of war wounds.

Primary suture, the ideal method of treatment of war wounds, reached this point but did not gather many disciples in spite of its evident advantages, when Tissier, in the course of investigations began at the end of 1915, in Flanders, and published in 1918[1] discovered that one never had severe infection in a war wound (particularly gas gangrene), when in the wound one could not demonstrate the presence of an anaerobic and aerobic infection. The nature alone of the germs living in a wound is important, Tissier claims; their number gives one no useful information. The works of Tissier can be summed up as follows: Each war wound contains a special microbial flora of its own on which depends its future development. The bacterial growth varies; it differs not only in different wounded men but even in different wounds of the same individual. Each microbe growing in a wound follows its own evolution and this process never varies. The microbe multiplies for a period, then the number remains constant, then decreases more or less rapidly, and at last disappears according to the power of resistance of the body to infection.

Infection of wounds is sometimes primary, sometimes secondary. In war times, as a wounded man passes through several hands in the course of his evacuation, it is difficult not only to control but also not to increase the primary infection. In every wound left open and uncovered, the number of new bacterial infections cannot help but increase.

Infection of war wounds usually pursues a purulent course of a type caused by the presence of quantities of putrefactive anaerobic organisms. Two conditions are necessary to cause these anaerobes to flourish in living tissue: (1) the presence of tissue either bruised or deprived of its blood supply; (2) the presence of one or several species or aerobic organisms.

The rate of tissue-destruction by anaerobic infection (gangrene) depends on the kind of aerobe with which it is associated and which seems to start the ball rolling. Thus, with the ordinary saprophytes, only slightly virulent, the anaerobic pus formation remains local; in conjunction with the staphylococcus pyogenus it extends slowly, whereas with the true streptococcus it spreads rapidly even attaining a fulminating type.

Infection of war wounds may also become of a purulent type when the wound has not become infected by anaerobes or when these bacteria are not able to develop. Under the conditions the type of aerobic microbe gives a special character to the wound. With the ordinary saprophyte there is hardly any reaction; with the staphylococcus local reaction, more or less marked; with the streptococcus there is at the same time a local and general reaction. It is in these latter cases that one meets those long-standing suppurations, metastatic abscess formations, bone lesions following febrile crises with marked temperature oscillations, and the slow cachexia which wears out the wounded man.

In these two kinds of wound infections, putrefactive or purulent, it is necessary to establish the nature of the aerobic infection present in order to form a prognosis. In serious cases it is always the streptococcus that is present.

The following rules may be deduced from these investigations:

1. Try, as a matter of course, primary suture, if removal of the foreign body and excision of dead tissue is possible. Establish at the same time the nature of the aerobic germ in the primary discharge in order to confirm your method of procedure. If the staphylococcus is present keep close watch of the wound for fear of the appearance of a slow form of pus formation which it will be easy to check, but which will not appear if the original dissection has been well done. A little pus may collect, necessitating the removal of a stitch or two. If one finds the streptococcus,

[1] H. Tissier. Bull. de la méd., 1918, Oct.; Ann Inst. Pasteur, 1915, Dec., 1917, Apr.; Arch de méd. milit., 1918, Dec.

remove the stitches at once and by widely opening the wound combat the further spread of the infection. Anaerobic growth hardly ever takes place before 30 hours. As you can secure a bacteriological report about 6 hours after culture in ordinary broth, there is no reason to fear that you will be too late in opening up the wound.

2. When primary suture has not been done, you must as quickly as possible perform secondary suture, being guided only by the nature of the aerobic infection. Here, also, you should take no notice of the presence of anaerobes. Their decrease begins about the third day and their development becomes impossible on the appearance of the phagocytes.

If the common saprophyte is found the wound must be sutured the second or third day. Results are always favorable. If the staphylococcus is present one must wait for its decrease between the fifth and eighth days. If the streptococcus is present one must wait for the period of spontaneous isolation of the organism. This is shown by a fall in temperature which usually commences about the twenty-first day, but sometimes earlier. The temperature remains down only when the wounded man becomes a mere germ carrier, without general reaction or, better still, when the streptococcus has definitely disappeared.

The practice of primary suture and early secondary suture (delayed primary suture) is thus built on definite, exact scientific lines which are founded entirely on Tissier's researches. It is only necessary to know the nature of the bacteriological infection; of the different types of infection the streptococcus alone contra-indicates primary suture of war wounds.

Since June, 1917, my collaborators and myself in the Twelfth Mobile Surgical Ambulance have depended on bacteriological reports. Our results were presented in two lengthy communications before the *Societe de Chirurgie*.[1] These results were such that they permit me to confirm the soundness of the theory of Tissier and to sum up thus: "Every war wound in which streptococcus is not present ought to be closed."[2] The results may be summed up as follows: 78.3 per cent of wounds met with were sutured; of the sutured wounds 88.8 per cent healed by first intention.

Several points should be studied in turn, in order to understand the technique of primary suture as it is practised. They are the following:

1. How do the sutured wounds progress?
2. How do we know whether a war wound contains streptococcus (bateriological technique)?
3. What surgical technique is to be followed to obtain constant results?
4. When must the suturing be done?
5. Its advantages.

How do the sutured wounds progress? Three things may happen. The wound may heal by first intention as in the ordinary aseptic operation, slight redness may appear, a stitch may cut out, or other insignificant thing happen to disturb the wound course; but regardless of this, healing finally takes place. Or again certain symptoms appear or bacteriological information is obtained which causes one to reopen the wound.

Sutured wounds may heal by first intention and this is the result in by far the greatest number of cases; 88.8 per cent was the result obtained in my ambulance. The stitches are removed about the tenth day and the scar is perfect.

Certain facts strike one in dealing with these wounds, the absence of pain being the most noticeable. Wounded men with unsutured wounds always suffer. Those with sutured wounds on the contrary never complain and certainly not after the second day, just as is the case with patients operated on in civil practice. In this manner they differ very greatly from the cases with wounds which have not been sutured. After the second day, in the sutured case, the patient, even if suffering from multiple wounds or fractures, feels perfectly well and begins to get up if he is wounded only in the upper arm. The facial expression is good, the color normal, the tongue clean, the pulse regular, and of good

[1] Bull. et mém. Soc. de chir., 1917, July 4, Oct. 10; Acad. d. méd., Paris, 1917, Oct. 23.

[2] Bull. Acad. de méd., Paris, 1917, Oct. 23.

volume. The temperature in most cases is slightly above normal, but often normal. In the majority of cases, it varies between 37° and 38° and falls to 37° rapidly. In some cases, however, it remains high for some time and rises above 38° for 4 or 5 days. Examination of the temperature chart is the only check necessary to keep on these patients who, however badly wounded, have the appearance of slightly wounded cases.

The dressing done at the operation is not removed before the tenth day. It is necessary to make sure that the suturing and the skin around look perfectly normal. Healing is perfect and when the stitches are removed we find perfect apposition of the edges of the wound. A simple protective dressing is applied and, as in all aseptic operations, the wounds cicatrize under the two dressings, and the patients are evacuated cured on the fifteenth and twentieth days. It must not be supposed that this healing will succeed only in minor wounds and that in them alone will one see healing take place with such ease. I have sewed up and have seen closed, wounds of the soft parts which were certainly 20 centimeters in length and of a really serious nature—such as amputations for crushes, resections of the thigh, arm, torn wounds of the buttock with the foreign body against the ischium, foreign bodies in the neck, various ligatures of the large vessels, wounds of large extent and very foul, dating back 24 hours or more. In a large number of cases the injuries consisted of fractures of which several were badly smashed up. In a number of these fractures (300), one sees better than in a sequence of ordinary wounds the splendid results obtained by primary suture. Such a large series of cases has never before been published.

Primary sutured wounds running an abnormal course. Side by side with wounds healing by first intention, one finds others pursuing a less normal course, which in spite of setbacks end by healing; in some cases normally and in others after a slight infection of limited amount. This fact has been evolved by careful attention to the temperature chart. The general condition of the patient remains good, the facial expression is bright, and the wounded man has a good appetite and is cheerful. The pulse is good in volume and tension, and in no case does it become small and rapid. Attentive study of the temperature chart alone gives one warning of coming events.

In the first type the temperature which during some days remained elevated to 38° or even 39° at night, falls slowly in 8 or 10 days or better still, with only a slight rise toward the fifth or sixth day, falling slowly afterward. I have already stated these facts in relation to joint wounds.[1] If the closed wound is examined there is found a little localized redness around one or several stitches. The region is slightly tense and swollen, but the findings remain quite local, and soon little points of pus appear at the stitch holes. The whole condition subsides and the wound remains closed, and the healing is but slightly delayed by this small superficial infection.

In the second type, the symptoms are not so mild; they present a more severe picture. On the one hand the temperature on the day of operation rises to 39° or 40°, remaining there two or three days and then falling suddenly to 37°, there remains or again mounts to 39° or 40°, falls to 37° not so rapidly, but in five or six days by degrees. If, however, during this rise in temperature, the dressing is removed the wound is usually found to be swollen and painful; but the skin remains normal in color. If between two horsehair sutures the point of a Kocher forceps is inserted and the blades are slowly opened, a little blood-stained fluid containing a few gas bubbles escapes. The healing will be none the worse for this, even if from a sense of prudence one has thought it wise to remove a stitch. The small wound resulting from this useless opening up prolongs the healing time a few days. These incidents, however, rarely occur (in about 5.01 per cent of cases).

In other cases, not only the vicinity of the sutures is a little distended and swollen but there appears a cherry red color extending some distance, giving an appearance which is disquieting to any one not acquainted with the course in such cases. The erythematous flush spreads toward the extremities of the limb and is sometimes accompanied by the presence of

[1] Soc. de. chir., 1916, October 18.

gas under the sutures, giving a resonant note on percussion, an unpleasant smell, and a blood-stained discharge which escapes between the stitches. But the wound has this characteristic appearance. Locally the erythematous flush is more cherry colored at the beginning than that of a gas gangrene and in general there is complete discord between the temperature on the one hand and the pulse and general condition of the patient on the other. Both remain excellent and this at once attracts the attention of the most experienced observer. In spite of these symptoms, it remains none the less true that only bacteriological examination giving assurance that the wound does not contain the streptococcus prevents the surgeon who understands the symptoms from opening up the wound. These cases are quite rare; in my experience there were not more than 1.18 per cent. However, following these acute symptoms we sometimes see develop a little suppuration and a gas abscess forms and must be opened up.

Voluntary opening up of wounds already sutured. This is necessary in a special kind of wound in which bacteriological examination has disclosed the presence of the streptococcus. Whenever the streptococcus has been definitely found, the wound must be opened up. Sometimes this is done at once after examination. In other cases there will be no symptoms which indicate what procedure to follow and the bacteriological report alone will be the guide. In such cases, the general condition of the patient is good, the temperature is only slightly raised, and the skin adjoining the wound has a normal appearance; for the infection has as yet had no time to develop. Some of these wounds which are not opened continue to heal without any great disturbance and untoward incident, and the skin keeps its color and texture. Toward the tenth day the stitches are taken out. Often the thickened edges of the wound gape a little and when the stitches are removed the wound opens spontaneously like a book. This is a sure sign of the presence of the streptococcus. It is then practically certain that if the wound is not voluntarily opened up, it will open itself and it is only running risks to leave it sutured. Usually at the end of a few hours, the wounded man is suffering and complains. His general condition is quite different from that of previously described cases. His expression is drawn, his pulse more rapid. The skin of the injured region is port wine red in color, with marbling (motley lines) spreading far and wide and gas escaping from the wound. This is the local gangrenous form. Destruction of the tissue has already spread though the wound has been widely excised. Can we assume that the suturing has caused this serious condition? I think not. This development well known to all surgeons at the front, is the same in wounds opened widely, drained, and left open. The suturing, too, may have been done only a few hours, but the wound so badly infected at the time of treatment has widely opened. In short, these fatal accidents ought to be the exception. I have seen but three such accidents in 759 sutured wounds, or 0.39 per cent. Men with such wounds die in the same way as do the cases with acute toxæmia, even before suturing can be done after an amputation, and the same symptoms and the same temperature curve are present. No surgical intervention can save them.[1] We are familiar with this form of virulent toxæmia which leads to a rapid and fatal termination, sometimes almost without development of gangrene and against which we are powerless.[2]

The wounded infected by the streptococcus present a typical picture: their facial expression is the same as that in long-standing seriously wounded and infected cases, they are pale, the pulse is rapid, the temperature fluctuating, and the appetite poor. The look of the ward where they are isolated is markedly different from the other wards. This, however, is to be expected. Since infection due to the streptococcus is all we have to fear, the wounded suffering with it should be isolated. It is strange that all surgeons still will not adopt this precaution although they isolate systematically and have for a long time each patient suffering with erysipelas, and the erysipelatous streptococcus is certainly much

[1] The general mortality of my ambulance, which like each surgical motor ambulance received only the seriously wounded, before doing sutures was 14.25 per cent. (G. Gross. Arch. méd. milit., 1916, October.) Since we do primary suture systematically the mortality is 10 per cent.

[2] Gross, G. 134 cases of gas gangrene. Soc. de chir., 1917, March 7.

less virulent than the streptococcus of war wounds.

Bacteriological reports upon which some light has been thrown by Tissier easily explain the incidents which may happen in primary sutures of war wounds. His investigations prove that the incidents come from a special pre-existing germ. There are exacerbations which can originate only in the wounds incompletely cleared of dead tissue.

How do we know whether a war wound contains the streptococcus? Primary suture of war wounds is based entirely upon the works of Tissier. It can be carried out systematically under bacteriological control. In my mind, the bacteriologist is as indispensable to the surgeon as is the radiologist. Besides, the report from the laboratory must be returned quickly so that the sutures can be taken from the wound a few hours after they are put in if the cultures have revealed the presence of the streptococcus.

The technique is the simplest: In the first place, as smears of pus and serum do not give exact indications, one should proceed only after cultural examinations. In fact, the only danger to be feared in primary suture of war wounds is the appearance of a putrid infection, which makes rapid progress. The cause of these terrible forms of infection is always an association of anaerobes and streptococci; it is quite necessary to inform the surgeon, as quickly as possible, of the presence or absence of the streptococcus. The only medium in which the streptococcus grows quickly is a liquid medium at 37°C. Within 5 or 6 hours there appears in the liquid lumps of long rolled up and absolutely characteristic chains.

Bacteriological specimens should be liberal and taken from all parts of the wound, chiefly from the deep parts near the bone when it is injured. It is best to use a pipette in order to collect a great deal of serum and particularly of blood as often as it is possible. The most convenient time for collecting the germs from a wound is between the tenth and eighteenth hours after the soldier is wounded. Sooner the bacteriological specimen would probably not contain all the different kinds of germs; and later, the considerable and predominant growth of anaerobes may hide the presence of aerobes, particularly of the streptococcus.

The inoculations should be made in broth upon slanted agar with litmus and lactose, and into deep agar of Veillon. Common broth is sufficient in the majority of cases; nevertheless, in order to facilitate the growth of streptococcus, it has been proposed that Sacqueppe's medium (that is, albumin of egg with soda—Raymond) or other albuminous medium such as ascites be added. Weinsenbach advocates water with peptone, glucose, and alkaline egg albumin; and Boyer a bone maceration with peptone.

These proceedings make it possible to obtain results most quickly if the wound contains the streptococcus—between the fourth and sixth hours; the streptococcus with its classical characteristics is more clearly demonstrated within the following hours. The broth remains clear, but a deposit is seen which, by shaking, changes into characteristic clots. When one has collected some blood there is hæmolysis, a very important phenomenon to establish. One can see much the same it is true among cultures of bacillus mesentericus or anaerobes; but, in these cases, the appearance of the cultures is different; there are no clots and the microscope permits a solution of the question. The slanted agar, with litmus and lactose, is turned red, is covered with tiny colonies, more or less transparent, fine, rather equally strewn upon the surface and, generally, separated from each other.

After staining one sees some gram-positive cocci, *in chains* of at least twenty cocci. As these are short in solid media, one will search for them preferably in liquid media (broth clots and water of condensation from slanted agar, at the bottom of the test tubes), where they are most often typical, very long, particularly rolled up and entangled. Short chains might be "enterococcus" but generally, this germ is more polymorphous; it does not produce hæmolysis and uniformly clouds the medium with a mucoid, thick deposit which rises up like a gimlet when one shakes the tube.

Within agar of Veillon, one will find the streptococcus very frequently; it grows easily in the presence of oxygen; but particularly

one will find the bacillus perfringens which is one of the first to appear, and also the most frequent.

The streptococcus is rather less frequent in recent war wounds (10 to 15 per cent), and the association of the streptococcus and the anaerobes even less frequent (6 to 8 per cent). It is important to bear these facts in mind for during the periods of intense work it is possible to examine only the wounds which are more likely to contain these infectious germs, i. e., deep ragged wounds, among thick masses of muscular tissue. Afterward, during more calm periods, systematic examinations can be made of all wounds.

What technique should be followed to obtain constant results? In most cases well done *exerese*. How is excision of war wounds best done? First the entire wound of entrance should be thoroughly excised. Then for a "seton" (the projectile having crossed the whole part of the limb), the cutting away of both orifices. The first is easy to do with an elliptical "incision," one circumscribes the orifices, sufficiently enlarging the "incision" so that later it will be possible to excise the deep part of the passage. The uncovered aponeurosis is laid open. By following the passage of the projectile, a broad excision of the muscular tissue which limits it can be done.

Exploration of the passage should be avoided whenever possible. Even with a smooth instrument, the end may penetrate the neighboring tissues and infect them. It is preferable to explore with the finger which acts as a guide in following the tract. Usually this questionable practice is useless for the direction of the passage can be demonstrated by radiology.

Excision, preceding suture, must be done with full knowledge of the conditions present. All blind exploration at the end of the finger must be avoided. When the track is outlined and after the projectile has been extracted, one practices wide "excision" layer by layer. The technique called *epluchage* is certainly inadequate; the word is badly selected; it instils in the surgeon's mind ideas of false security. With *epluchage* primary suture does not bring success but disasters. One must practice wide *exerese* of the devitalized tissues. It is quite useless in order to determine the amount of tissue to be excised to color the wound with methylene blue; the experienced surgeon will stop the excision in time; that is to say he will cease to excise when he reaches muscular fiber which is not deprived of its blood, which has not the dark port wine color or has not the well known soft consistence; in other words when the tissue has become firm, is contractile, and is red in color; in short when it bleeds.

Three typical procedures may be employed:

1. Opening and laying open of a "seton" (the projectile having crossed through all the soft tissue); or of a wound with projectile included under the skin. One cleaves the track if it is not too deep, then extirpates it completely, *en bloc*.

2. Extirpation *en bloc* of the entire wound when it is superficial or even when deep and widely laid open.

3. Usually the lesion is deep and the incision must be conical, the top of the cone being beyond the projectile or upon the fracture. This excision systematically made, with scissors, takes away layers of devitalized tissues. It must be made thoroughly, carefully, systematically, reaching the seat of injury where the projectile is lodged. For a deep "seton" (in the upper part of the thigh, for instance), one must do a double conical excision, the tops of which will join. Bony lesions neither can nor must cause a total *exerese*. In a fracture one must always be satisfied to remove carefully all the free splinters not adherent, and sometimes with one stroke of the bone forceps to make regular the sharp fragments. One must always leave the adherent splinters which are so useful. I plainly condemn removing large pieces of bone, a procedure I have, alas, so often seen practiced. Tissier showed that the cutting away of free splinters is sufficient. Clinically, we have already learned that the bones become infected slowly, through the soft parts, and consequently operations upon bones must not always be extensive ones.

If the projectile is situated within a diaphysis or an epiphysis, the tract and chamber shall be carefully hollowed out, enlarged, and if possible laid flat. The cavity should be

touched with iodoform ether. It can be filled in different ways. No one among my collaborators ever tried plastic pastes; but one of them (Houdard) used, with good results in four cases, fat grafts taken from the buttock.

In the treatment of injured joints, as often as it is anatomically possible, the ideal method is the operation of Loubat. Primary resection is the best method in the majority of lesions, typical or atypical resection according to the extent of the lesions. No matter what the anatomical lesion, or how thoroughly excision has been done, it will not be complete, naturally, without the extraction of the projectile and bits of clothing. The useful antiseptics are: ether for flesh wounds (soft parts) (ombredanne) and iodoform ether for bone injuries. The technique of the suture itself remains to be described. Sometimes it is useful to suture the deep muscular layer with catgut. I do not like this method as I have noticed that these catgut sutures easily become infected. Two conditions are most important in order to obtain a good suture; perfect hæmostasis and care not to leave a dead space under the sutured skin. One can perform a good closure with rolled-up gauze and three or four bronze wires. After the bronze wires are carefully placed, approximation of the skin edges is brought about with horse hair. Then there is placed over the suture line a pledget of rolled up gauze (called in French a *bourdonnet*) and the bronze wires are tightened over it. The *bourdonnet*, when it is not soiled by oozing, is taken off only when the cutaneous horsehair suture is removed. It is preferable to remove the horsehair suture slowly, about the tenth or twelfth day, for the process of healing of the war wound is slower than is that of aseptic wounds in civil practice.

When should the suturing be done? In any case where no streptococcus is found in the wound and when there exists no anatomic or pathologic contra-indication. Practically every wound may be sutured upon arrival of the wounded man; but one must always reopen those wounds in which within 6 hours, the bacteriologist has found the presence of the streptococcus.

Does the time elapsed between the receipt of the wound and the arrival at the hospital contra-indicate operation? I do not think so. Certainly the longer the interval that has elapsed the more infection could develop; but with thorough excision I have myself sutured and have seen sutured wounds which had been received 12, 24, and more hours before, and correct and simple reunions resulted. It seems to me one can find in these facts a greater proof that, in deciding upon the technique to follow, one need bear in mind only the type of infectious germ found in the wound; a wound containing the streptococcus must not be sutured after a few hours, those containing only common saprophytes can be sutured after 24 hours or more. Where suturing is contra-indicated the wounds should be left open. In my mind, suture is contra-indicated in the following cases:

1. In multiple wounds when the patient is suffering from shock, yet in condition to be operated upon, but where it is necessary to do the operation very quickly.
2. In deep wounds, the complete excision of which is impossible; wounds which appear to be badly infected; very old wounds or wounds communicating with septic cavities, and wounds with increasing gaseous gangrene.
3. In wounds with projectiles remaining in them.
4. In wounds with great vascular lesions.
5. In wounds producing extensive injury to the skin.
6. In wounds which do not require suturing (enucleation of the eye).

Most of these contra-indications do not need explanation. Certainly suture lengthens the time of operation. When it is necessary to operate quickly upon the multiwounded man who is in a serious general condition, it is preferable to save his life. The final results will be a little less brilliant. However, one can operate and suture the multiwounded man if he is not suffering from shock. In those suffering from shock one should be satisfied to suture the principal lesion (joints or bones) only incising and draining, or even neglecting the less important lesions, which will be treated later. The correct and complete excision of infected and devitalized tissue is the principal requisite for a successful primary

suture. When the operator cannot do this, he must leave the wound open. When the projectile has not been extracted, the same contra-indication exists, if the projectile is small (green pea); or if it is extremely small, one can suture leaving within the tissues one or several projectiles. I have often done this, and have seen it done. I do not think one can advise against suturing wounds in a period of intense activity; in my ambulance, three operators sutured 49 gravely wounded men within 24 hours.

Nevertheless, when a considerable number of wounded men overflow the ambulance and when one has not sufficient room for keeping all the wounded men, it might be well not to perform primary suture, but follow Pierre Duval's technique,[1] i.e., delayed primary suture. At first the wound is widely opened and the excision is done. Then, the wounded man is evacuated to another sanitary center situated at the base (*Zone des Etapes*) where the wound can be sutured after two or three days. According to the author's advice delayed primary suture is founded also upon the works of Tissier. In these cases it remains only a necessity; primary suture is preferable. Certainly delayed primary suture has some disadvantages, the principal one being the necessity of giving two anæsthetics and of doing two successive operations. Time and money are lost. If such a procedure is necessary in certain cases, we must practically always try to do primary suture.

ADVANTAGES

The advantages of primary suture are unquestionable. The wounded men do not suffer so long; they completely escape the grave danger of secondary infection, so frequent among open wounds. One can state a comparison: in the hospitals of the interior 80 per cent of the wounded men showed streptococcus in their wounds, while among the recently wounded they were found in only 10 to 15 per cent. Among cerebrocranial wounds within the first months after suture, the mortality descended from 14 to 10 per cent, since we have systematically performed primary suture. Functional restoration is likewise obtained more completely and quickly. It is obvious that a flexible, non-adherent scar would not be likely to produce a neoplasm and this has been rather frequently seen in cases with old adherent scars. Besides, these first advantages, from the economical standpoint, there are several factors of first importance. Fewer attendants are necessary, there is less shock, as most of the wounded men become cured with only one dressing, as in civil practice; nowadays due to the great necessity of recovering cotton, it is easier to recover unsoiled cotton and the outlay of cotton is less; there is considerable economy of hospital days and annuities as the wounded men are cured more quickly and the end-results are better. Finally, from the military point of view, this method is of capital importance. All the cases, with large wounds of the soft parts, are entirely cured about the twentieth day and are able to resume work. Those with fractures leave the ambulance with closed fractures often already united. One of my evacuations contained 59 primary reunions among 61 wounded. The requisites for obtaining constant results are as follows:

Place by the side of a competent surgeon (having correct technique) a competent bacteriologist. Let them keep their wounded men a sufficient length of time to follow them until they are completely healed—about fifteen days. In proving that all war wounds containing no streptococcus can be sutured and thus cured Tissier has permitted us to realize the greatest progress obtained in war surgery since the beginning of hostilities. Until then primary suture was an uncommon procedure. Thanks to these works it is now a regular routine: in the future I am certain it will be the rule.

[1] Pierre Duval., Soc. de chir., Par., 1917, Oct.

DEPARTMENT OF TECHNIQUE

A METHOD OF EXPOSING THE MUSCULOSPIRAL AND THE POSTERIOR INTEROSSEOUS NERVES

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IN the repair of extensive injuries of the musculospiral nerve it is frequently necessary to expose the nerve in the greater part of its course. Many times, both above and below the injury, the nerve must be identified and followed in order to find the severed ends. The more usual method is the spiral incision beginning below and following the line of the nerve. There are certain disadvantages to this incision. Unless it is made precisely over the nerve, considerable difficulty may be met in locating it and further dissection of the tissues becomes necessary. It is sometimes extremely difficult thus to find the nerve even when the incision approximates fairly closely its position. Such is the disadvantage of any incision which runs parallel to a nerve, particularly if it follows a winding course. Furthermore, the spiral incision cuts the triceps transversely. If it is directly over the nerve it places a scar down to the nerve throughout the greater part of its course. When nerve graft or tubulization is to be done the danger of infection and further scar formation is thus increased. For the above reasons the spiral incision usually employed is unsatisfactory.

The authors present the three following incisions for the exposure of the musculospiral nerve from the lower border of the teres major muscle down to the antecubital fossa.

The first incision lies in a line from the tip of the olecranon to the posterior angle of the acromion. The incision should begin three fingers, breadth below the acromion and continue directly downward along the above line to 5 centimeters below the level of the insertion of the deltoid. The incision is carried directly through the deep fascia. At the upper angle of the wound the posterior border of the deltoid and the long and outer heads of the triceps can be identified. These heads of the triceps are separated in their fascial plane by blunt dissection. The deltoid is retracted. If necessary, a small part of the latter muscle may be cut. The separation of the two heads of the triceps is carried down to the lower angle of the wound, following as closely as possible their line of junction. After separating the muscle fibers a glistening aponeurosis presents; this is incised and the nerve exposed up to the lower border of the tendon of the teres major muscle. The exposure thus gained is excellent and little damage is done.

The second incision runs parallel to the first except in its lower part, where it is slightly curved toward the anterior side. This incision should begin about 12 centimeters above the antecubital fossa external to the brachialis anticus and between it and the almost longitudinal fibers of the supinator longus (the usual incision is generally not sufficiently perpendicular and lies too far anterior — near the belly of the biceps). If this second incision is correctly placed, it will fall over the interspace between the brachialis anticus and the supinator longus in which the lower third of the musculospiral nerve is to be found. By careful dissection the nerve can be traced into the antecubital fossa to the point at which it divides into the radial and the posterior interosseous.

The nerve in its upper and lower thirds is thus exposed. By carefully following the course of the nerve in the fascial space beneath the triceps and through the intermuscular septum by means of a blunt dissector a groove may be opened. By utilizing the canal thus opened, severed ends of the musculospiral nerve might be united by means of nerve grafts or other procedures without further dissection. However, should a more complete exposure be required, a third incision may be made midway between the other two and par-

[1] On special detail in experimental nerve surgery under Dr. Huber, Director of Anatomy, University of Michigan.

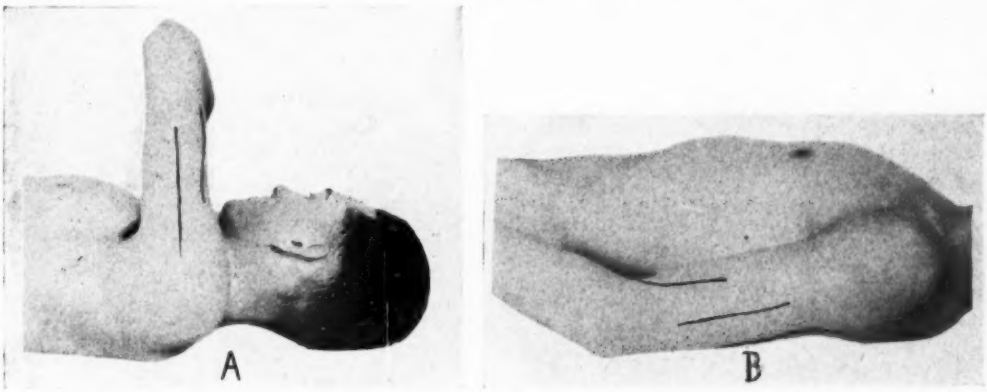

Fig. 1. Lines of incision for exposure of the musculospiral nerve.

A. The position of the skin incision for exposure of the upper third of the musculospiral nerve is here seen. It is placed on a line from the lateral part of the posterior angle of the acromion to the tip of the olecranon and extends from three fingers' breadth below the acromion directly downward in the long axis of the arm for about 12 centimeters. The incision for exposure of the middle third of the nerve may also be seen. (The apparent curvature of this line is due to perspective — it is actually a straight line parallel to the first.)

B. The lines of incision for exposure of the lower and middle thirds of the musculospiral nerve are here shown. The lower incision is made very nearly perpendicular, except in its lower fourth where it turns slightly anteriorly. It should be external to the brachialis anticus and between it and the perpendicular fibers of the supinator longus. Generally this incision is placed too far anteriorly and is curved more than the nerve. The incision for the middle third of the nerve lies midway between those made for the upper and lower thirds and parallel to the former. It is placed upon the outer head of the triceps and extends from a point 3 centimeters above level of insertion of the deltoid directly downward for about 12 centimeters.

allel to the first. It should extend from 3 centimeters above the level of the insertion of the deltoid directly downward for about 12 centimeters. The incision is carried through the triceps, separating the fibers longitudinally until the aponeurosis on its deep surface is seen. This is carefully incised and the nerve exposed directly beneath. A complete new skin incision need not be performed. Either of the above incisions may be prolonged in an oblique or curved manner and the skin edges undermined. The additional exposure is then obtained by carrying the incision as above described, longitudinally through the deep structures. This incision is close to that given by Schwartz and Kuess. Both of them alone give free exposure of the musculospiral nerve only in its middle third.

These three parallel longitudinal incisions expose the musculospiral nerve from the lower border of the teres major muscle to the antecubital fossa with the least possible damage to the overlying tissues. The muscle fibers when cut longitudinally are damaged but little, and the sensory skin supply, frequently completely destroyed by a spiral incision, is in a great measure retained. Thus the main objections to a spiral incision are avoided and a free and easy exposure obtained.

The rather perpendicular course of the musculospiral nerve is not anticipated from the usual anatomical descriptions. The nerve is essentially perpendicular in its upper and lower thirds, being spiral only in a small portion of its middle third. Perhaps this is the reason why a spiral incision frequently does not lie over the course of the nerve, the precise position of which it is difficult to estimate. In such cases considerable dissection in further efforts to find the nerve must be undertaken.

Posterior interosseous nerve. This nerve is not infrequently severed or involved in callus following injuries of the radius, particularly in explosive wounds of the elbow-joint in which the radius may be shattered. When injured it causes considerable disability due to paralysis of the extensors of the thumb and fingers. The extensors of the wrist receive their nerve supply by branches above this level. The technique of suturing the posterior interosseous is rendered difficult both by its relatively small size and by its inaccessibility.

For this exposure the arm is slightly flexed across the lower abdomen with the hand semipronated. The prominence of the external condyle and the radial border of the extensor communis digitorum are identified. By rapidly mov-

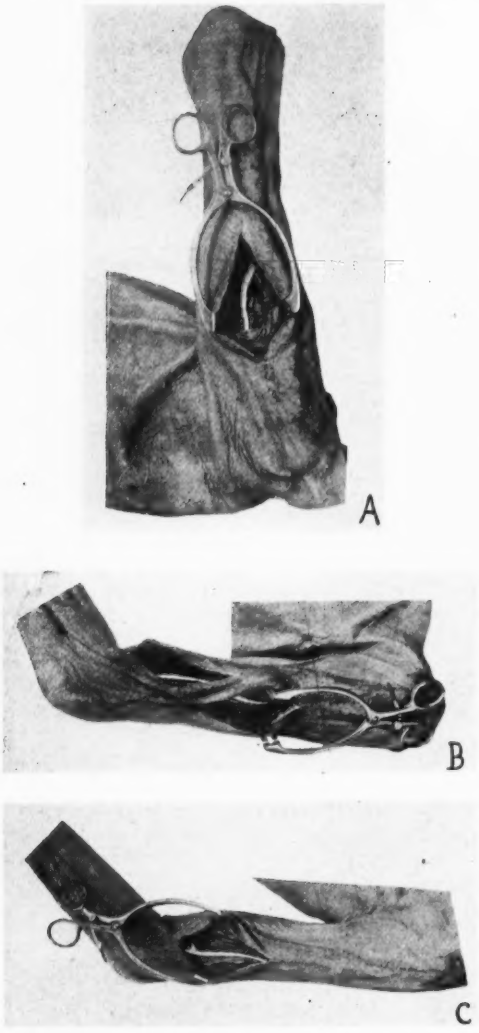

Fig. 2.[1] The musculospiral nerve exposed in its upper, middle and lower thirds.

A. This shows the exposure of the upper third of the musculospiral nerve. The outer and long heads of the triceps are retracted. The tendon of the teres major can be seen lying across the nerve in the upper angle of the wound. Beside the nerve are the superior profunda vessels. Note the almost perpendicular course of the nerve in its upper third.

B. This shows the exposure of the middle third, and most of the lower third, of the musculospiral nerve. In the upper wound the fibers of the outer head of the triceps are split longitudinally and separated. The inferior incision shows the lower third of the nerve lying between the brachialis anticus and the supinator longus.

C. The lower third of the musculospiral nerve is exposed into the antecubital fossa to the level of its terminal branches. Note the comparatively perpendicular position of the nerve. It does not have the spiral direction in this part of its course that most descriptions indicate. The nerve here lies between the brachialis anticus internally and the supinator longus externally.

[1] The illustrations in Figures 2 and 3 are from photographs of exposures of the nerve in a cadaver.

Fig. 3. Exposure of the posterior interosseous nerve.

A. The extensor communis digitorum, including its deep aponeurosis, and the extensores carpi radialis are widely separated, exposing the supinator brevis. At a point two fingers' breadth below the external condyle the fibers of the supinator brevis are separated with two tissue forceps in the direction of their course. The posterior interosseous nerve is thus found running at almost right angles to the fibers of the muscle. From this point the nerve can be readily followed in its course.

B. The posterior interosseous nerve is here shown as finally exposed. It has been followed from its point of exposure shown in *A* both upward and downward by a careful incision of the supinator brevis along the line of the nerve. Danger of cutting the nerve before it is located is avoided by this procedure. The nerve may be followed until it breaks up into its main branches. By also making the incision shown in Figure 2, *C*, the posterior interosseous and the lower third of the musculospiral may both be exposed. It is in the lower angle of the latter wound that the posterior interosseous branches from the musculospiral.

ing the various fingers, without extension of the wrist, the common extensor may be recognized. External to it lie the extensores carpi radialis. An incision 12 centimeters long is carried from the external condyle directly downward along the line between the extensor communis digitorum and the extensores carpi radialis through the deep fascia. Beginning at the lower angle of the wound, the interspace between these muscles is identified and they are separated by blunt dissection as far as their common origin. Here the muscle fibers are cut longitudinally up to the external condyle. This last step is essential in order to obtain adequate exposure. The muscles are then widely retracted and the common extensor aponeurosis on the deep surface of the muscle mass exposed. Its free medial border can be readily found, freed by blunt dissection and retracted with the extensores carpi radialis, thus exposing the obliquely running fibers of the supinator brevis. These fibers run anteriorly and downward toward the flexor surface of the forearm. The posterior interosseous nerve is within or beneath this muscle. It runs at almost right angles to the muscle fibers diagonally across the radius toward the extensor surface. At a point two fingers' breadth below the condyle, the fibers of the supinator brevis are separated in the direction of their course by blunt dissection with two tissue forceps. In the opening thus made the flat posterior interosseous nerve will be seen (see Fig. 3, *A*). Having thus found the exact position of the nerve the supinator brevis is cut both above and below, thus exposing it freely without danger of injury. The posterior interosseous nerve is thus laid bare in the main portion of its course. Without the step involving the separation of the muscle fibers by blunt dissection at right angles to the nerve, difficulty may be encountered in finding it. It should be a principle of nerve surgery never to attempt an incision parallel to a nerve having a spiral course. The slightest error in placing the incision necessitates further difficult dissection and needless destruction of tissue. Should it become necessary to expose the posterior interosseous nerve higher than this incision affords, the lower incision described above for the musculospiral nerve should also be made.

The authors believe that this technique for exposure of the musculospiral and posterior interosseous nerves from the teres major muscle to the termination of the main stem of the latter has distinct advantages over the usual spiral incision. By longitudinal incisions running across the course of the nerve it is immediately found without additional search.

NECESSITY FOR SPECIAL POSITIONS IN THE ROENTGENOGRAPHIC STUDY OF SHOULDER CASES

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IN the roentgenographic study of the shoulder-joint, the usual routine anteroposterior plates are not sufficient, and a negative diagnosis based upon such plates is open to severe criticism.

George[1] has recently emphasized the necessity of multiple plates and especially plates in abduction and external rotation for the recognition of shadows occurring in so-called subdeltoid bursitis. The position he found most valuable was as follows: "With the patient in the recumbent posture, the affected shoulder flush on the plate, the upper arm abducted to a right angle, rotated outward, the forearm flexed at the elbow to about 45 degrees and the opposite shoulder slightly elevated by a sandbag."

[1] George. Am. J. Roentgenol., 1918, v, 187.

For the past five years, we have been using, as a routine in the examination of shoulder cases, a somewhat similar position, differing only in the degree of abduction. With the patient supine, the forearm has been flexed at the elbow and the upper arm fully rotated externally. By this procedure, there is some abduction of the humerus, but not to the degree recommended by George. This would seem to be an advantage as the degree of pain produced is apt to be proportional to the degree of abduction.

The especial value of this position of extreme external rotation is that the greater tuberosity of the humerus and the tissues attached thereto are brought into profile, whereas in the ordinary position the greater tuberosity lies on the anterior

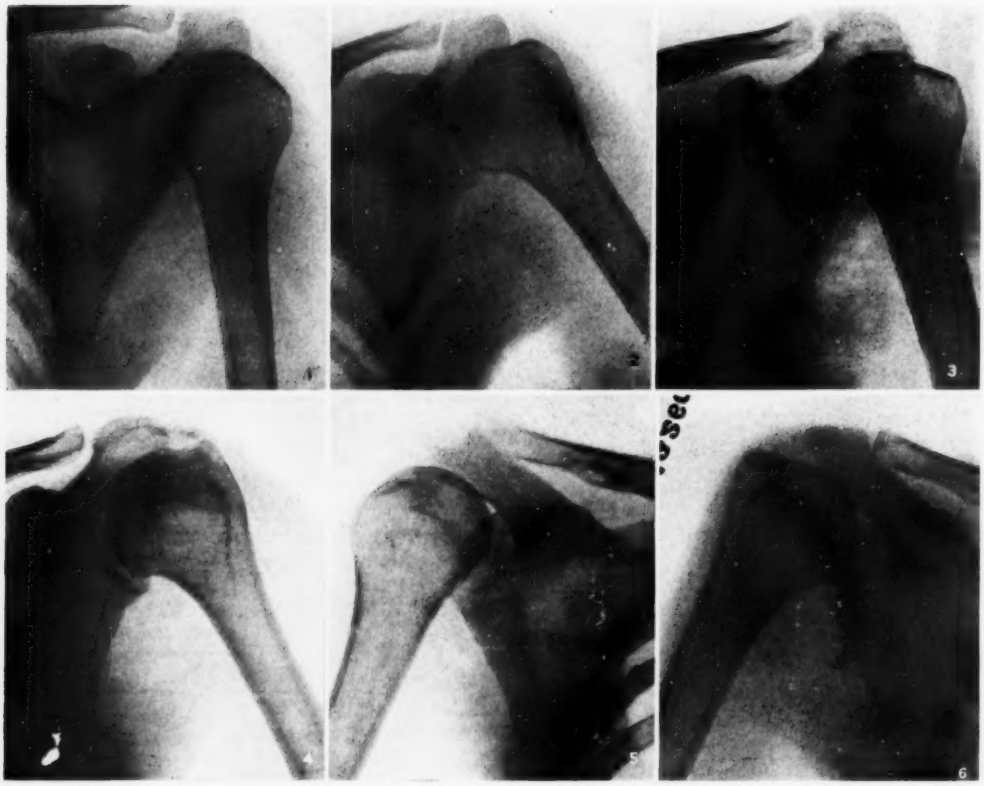

Fig. 1. View of shoulder in ordinary position.
Fig. 2. View with forearm flexed and extreme external rotation of the humerus.
Fig. 3. So-called subdeltoid bursitis, ordinary position.
Fig. 4. Same shoulder in extreme external rotation.
Fig. 5. Injury of shoulder, ordinary view.
Fig. 6. Same shoulder showing definite fracture of greater tuberosity.

surface of the head of the humerus. This is well illustrated by Figures 1 and 2.

We thoroughly agree with George regarding the value of such a position for discovering abnormal shadows beneath the acromion process. This is well illustrated by Figures 3 and 4.

We also wish to emphasize the absolute necessity of such positions for the recognition of fractures of the greater tuberosity. During the past few years we have seen several cases in which the routine anteroposterior plate appeared perfectly normal, but in which the plate of the externally rotated arm disclosed a fracture of the greater tuberosity (Figures 5 and 6).